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Heavy Metal Contamination
of Powdered Protein and
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ABOUT THE COVER



The use of powdered shake mixes as nutritional supplements or meal replacements has become increasingly popular among health-conscious individuals. Consumption of these mixes, however, might pose a public health risk due to possible contamination of harmful substances such as heavy metals. This month's cover article, "Heavy Metal Contamination of Powdered Protein and Botanical Shake Mixes," analyzed a select group of popular powdered protein and botanical shake mixes for arsenic, cadmium, chromium, and lead. Over half of the products tested contained elevated levels of at least one toxic heavy metal. The findings highlight that these types of mixes can be a significant source of exposure to toxic heavy metals.

See page 8.

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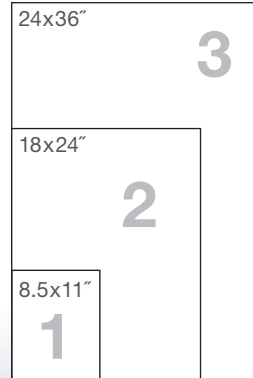


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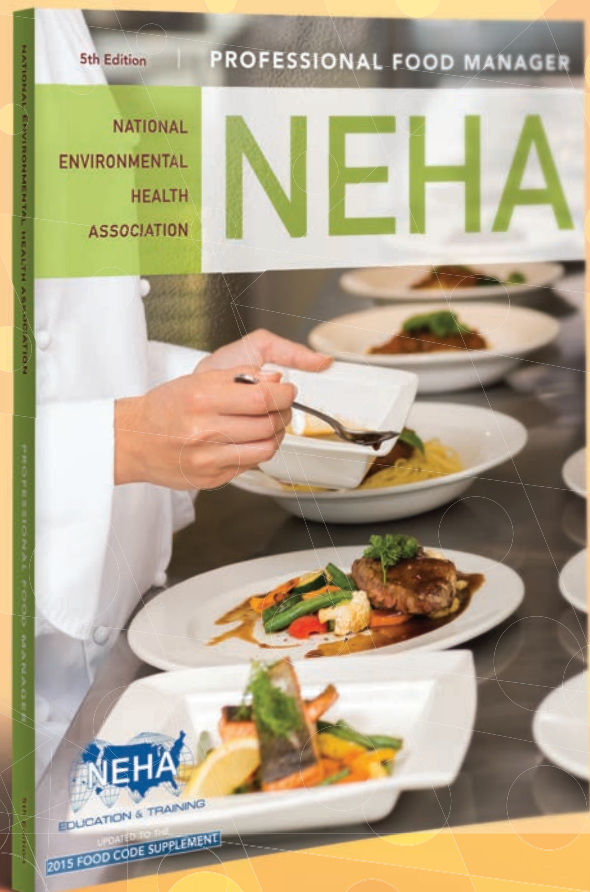


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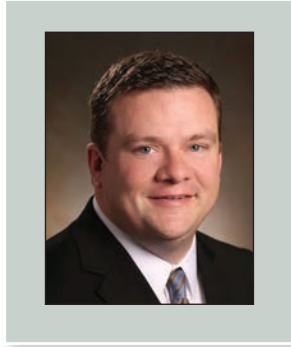
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▶ PRESIDENT'S MESSAGE



Adam London,
MPA, RS, DAAS

Gratitude Served With a Side of Sacrifice

Autumn has always been my favorite time of year. The leaves are turning colors in most parts of the U.S. as you read this November issue of the *Journal of Environmental Health*. Football season is well underway and the London kids are carving pumpkins. Hopefully most of you are making plans to spend Thanksgiving with your family and friends.

As I write this column, I am well aware that many of you are still recovering from the aftermath of September's severe hurricanes. My thoughts and prayers are with you, as well as with the many organizations working to deal with the environmental health concerns that will linger for quite some time. I am deeply thankful that our nation has such tremendous professionals responding to natural disasters such as this one, even though society does not often recognize the work that you, as second responders, do to protect it from illness and injury. I believe Thanksgiving is one more opportunity to tell our story and encourage people to help those in need.

If your extended family is anything like mine, there are a couple of questions that invariably arise around the Thanksgiving turkey feast or during halftime of the Lions game. The first question is usually related to work ("Tell me again, what exactly do you do at work?") or the latest outbreak in the news. The second is the traditional question that asks what we are thankful for this year. Sometimes we delve into deeper conversation about the first Thanksgiving, wondering with curiosity what the Pilgrims and their Native American friends might have discussed. As you know, so much of world history is deeply

*You make the
world a better place
every day through
your work.*

influenced by environmental health. I am sure that the first Thanksgiving was no different. I am certain that there was thankfulness to God, new friends, and new beginnings in America. But make no mistake, environmental health played a role in the story of the Pilgrims, their Native American friends, and the events that preceded the first Thanksgiving.

The Mayflower contained around 130 people when it arrived at Plymouth, Massachusetts, in November 1620 after a long and difficult journey across the Atlantic Ocean. When the Pilgrims explored the nearby wilderness, they found an abandoned "Indean" village full of "sculs and bones." What they did not know was that this village had recently been decimated by a mysterious plague. Up until recently, it was believed that this outbreak was caused by smallpox. Researchers now believe it was leptospirosis that killed most of the Wampanoag tribe living in that small village. Leptospirosis is caused by a spirochete bacterium spread environmentally through the urine of infected rats and other animals. The illness usually manifests with yellowing of the skin, reddening of the eyes, fever, vomiting, diarrhea, and hemorrhaging. The

rats and the *Leptospira* bacteria they carried were both invasive species brought to North America by earlier European vessels. It is likely that rat urine containing this infectious agent contaminated grain stores, drinking water supplies, and surfaces throughout the village. Historians estimate that 90% of Native Americans in this area died between 1616 and 1619 from this outbreak of leptospirosis. While people of that time did not understand the complexities of disease transmission, they certainly understood that there was something gravely disordered and dangerous happening. The few survivors hastily abandoned their homes and fled into the wilderness to join other bands of Wampanoag.

Meanwhile, the Pilgrims were not faring much better. They spent a good deal of that first winter on the moldy Mayflower with rodents and lice. As you can imagine, the sanitation of their food and water supply was terrible. They had marginal wastewater disposal. During early 1621, they were food insecure and exposed to the harsh elements of a new world. Scores were dying from a litany of illnesses. Various sources report that causes of death included tuberculosis, pneumonia, smallpox, dysentery, and leptospirosis. The Pilgrims worked hard during 1621 to build safe shelter, identify food supplies, find safe water sources, and improve sewage management.

The amazing circumstance through which the Pilgrims encountered the English-speaking Squanto amongst the Wampanoag survivors speaks powerfully to the importance of diversity, inclusion, and loving "thy neighbor." Squanto taught the Pilgrims how to cultivate the most successful crops for this region:

beans, maize, and squash. By November 1621, the condition of the Pilgrim settlement had stabilized, but only around 50 of them were still alive. They were, however, grateful to God for bringing them through those tough times. We often default to the imagine of the first Thanksgiving exclusively from the perspective of the Pilgrims. The people of the Wampanoag tribe also had some cause to be thankful in 1621. Despite the horrible plague of leptospirosis, a remnant of their tribe had survived to see a bountiful harvest.

There are many lessons for us to reflect upon in the story of the first Thanksgiving. As people of the post-germ theory world, we have collective amnesia about the morbidity and mortality our ancestors endured due to things that we now prevent from happening.

Our modern storytelling of the first Thanksgiving often neglects the extreme suffering of the Pilgrims and Wampanoag. I cannot help but think that a few sanitarians equipped with the basic knowledge of our science could have prevented many of their deaths.

Another important lesson is the reminder to be good to one another, care for those in need, and work for healthier communities for all. These lessons are central to our profession of environmental health. You make the world a better place every day through your work.

Thank you for your work. I do, however, want you to sacrifice a little bit more this month. While we cannot go back in time to help the Pilgrims and Wampanoag, we have an opportunity to help other people who are housing insecure and faced with serious envi-

ronmental health hazards in the hurricane disaster zones. I challenge each of you to donate at least \$10 to the American Red Cross or another disaster response organization of your choosing. You may ask, "What good is \$10 going to do?" There are approximately 5,000 members of the National Environmental Health Association and together we could easily raise a difference-making \$50,000 by simply skipping a lunch. Please do it now, and then go tell your relatives that the first Thanksgiving is really a story about surviving environmental health disasters. 🐾



adamelondon@gmail.com

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Individuals who have contributed to the foundation are listed below by club category. These listings are based on what people have actually donated to the foundation—not what they have pledged. Names will be published under the appropriate category for one year; additional contributions will move individuals to a different category in the following year(s). For each of the categories, there are a number of ways NEHA recognizes and thanks contributors to the foundation. If you are interested in contributing to the Endowment Foundation, please call NEHA at 303.756.9090. You can also donate online at www.neha.org/about-neha/donate.

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Heavy Metal Contamination of Powdered Protein and Botanical Shake Mixes

Christine F. Skibola, PhD
 Emory University School of Medicine
 University of Alabama at Birmingham

Jianqing Zhang, PhD
 Jacques E. Riby, PhD
 University of Alabama at Birmingham

Abstract The increasing popularity of powdered shake mixes as nutritional supplements or convenient meal replacements, combined with the complex formulations incorporating multiple ingredients of unknown origin in many of these products, might pose public health risks because of possible contamination with harmful substances such as heavy metals. Our aim was to determine levels of four heavy metals in a select group of popular powdered protein and botanical shake mixes purchased from local stores specializing in sales of whole/organic foods. To measure levels of arsenic, cadmium, chromium, and lead, analyses using inductively coupled plasma dynamic reaction cell mass spectrometry were performed. In 56% of the products individually tested, metal levels for one daily serving exceeded the daily thresholds and standards recommended by various regulatory agencies, particularly for rice-based shakes. This study highlights that commercial shake mixes can be a significant source of exposure to toxic heavy metals and emphasizes the need for consumers to limit their exposures to these metals.

Introduction

Meal replacement shake mix powders and beverages have become increasingly popular among health-conscious individuals who consider meal replacement shakes an integral part of a healthy diet. Moreover, the growing emphasis of muscular and fit male and female images in the media has greatly boosted the use of muscle-enhancing or weight-loss shakes and beverages among adults and teens alike. In fact, a U.S. study that surveyed 2,793 middle school and high school students to determine their muscle-enhancing behaviors found regular use of protein powders or shakes among 35% of the teens surveyed (Eisenberg, Wall, & Neumark-Sztainer, 2012). Protein, mainly in the form of whey, rice, and pea, is the most common

ingredient in commercially available shake mix powders. A number of “whole food” botanical shake mix powders and elixirs also have become popular that contain fruit and/or vegetable extracts, vitamins, minerals, and various other ingredients.

Shake mixes are manufactured by multiple brand names and are readily available at retail stores, especially those that specialize in sales of organic and genetically modified organism-free foods and nutritional supplements. In contrast to over-the-counter drugs, the quality of dietary supplements, including shake mixes, is largely unregulated. With the large variety of ingredients of unknown origin, quality, and processing methods used, there is a potential risk of contamination by harmful and toxic elements such as heavy

metals that could have adverse health effects for consumers of these products. Heavy metals are not readily metabolized and excreted; therefore, they can bioaccumulate over time, which poses additional health risks through repeated exposures.

According to a *Consumer Reports* study (2010), 20% of 15 protein powders/drinks that were tested for heavy metal contamination exceeded the maximum allowable limits for arsenic (As), cadmium (Cd), and lead (Pb) set forth by the nonprofit U.S. Pharmacopeia (USP) for three daily servings (USP, 2015). USP is a federally recognized authority that sets voluntary standards for the identity, strength, quality, and purity of medicines, food ingredients, and dietary supplements. Arsenic and Cd are classified as Group 1 carcinogens by the International Agency for Research on Cancer (IARC) (World Health Organization [WHO], 2012), and Pb is a known neurotoxicant in humans, particularly in children (Sindhu & Sutherland, 2015). Thus, the findings of potentially harmful heavy metals in shake mix products warrant further studies.

Though not included in the *Consumer Reports* 2010 analysis, hexavalent chromium [Cr(VI)] is a human and animal carcinogen and contaminant of agricultural water and soil that is readily absorbed by crops (WHO, 2012; Witt et al., 2013). Oral exposure to Cr(VI) is widespread and is known to adversely affect many people worldwide (Sun, Brocato, & Costa, 2015); thus, high levels of chromium (Cr) found in foods might also be of toxicological significance.

To further investigate the potential relevance of toxic heavy metal contamination in commonly consumed protein- and botanical-

TABLE 1

Arsenic (As), Cadmium (Cd), Chromium (Cr), and Lead (Pb) Levels in Five Pools of Three Commercially Available Shake Mix Powders

Main Ingredients	Pool #	ppm ($\mu\text{g/g}$)				Serving Size (g)	$\mu\text{g}/\text{Single Serving}$			
		As	Cd	Cr	Pb		As	Cd	Cr	Pb
Whey	1					45				
Pea, hemp, brown rice proteins		0.022	0.029	0.271	0.023	34	0.82	1.08	10.12	0.86
Egg albumin						33				
Whey	2					30				
Whey		0.009	0.001	0.030	0.003	23.3	0.23	0.03	0.76	0.08
Whey						23				
Pea, hemp, brown rice proteins	3					23				
Brown rice proteins		0.043	0.292	0.320	0.148	18	0.90	0.61	6.72	3.11
Rice and hemp proteins, wheat and barley grasses, flax seed						22				
Sprouted brown rice proteins	4					16				
Spirulina; wheat, barley and oat grasses; alfalfa		0.766	0.407	0.142	N/A	12.1	9.73	5.17	1.80	N/A
Barley, alfalfa, oat, wheat and kamut grasses; fruits and vegetables juices						10				
Spirulina, apple fiber, barley and wheat grasses, sprouted barley malt	5					8.9				
Whole leaf wheat grass powder		0.102	0.077	0.865	0.210	8	0.85	0.64	7.18	1.74
Wheat and barley grasses, alfalfa, spirulina						8				

Note. The bolded value represents amount in excess of recommended daily maximum limits: As, 10 μg ; Cd, 4.1 μg ; Cr, 150 μg ; and Pb, 20 μg .

based meal replacement/shake mix powders, we purchased 30 powdered shake mixes from large nationwide chain stores located in the Birmingham, Alabama, area and tested them for As, Cd, Cr, and Pb.

Materials and Methods

Product Description

A total of 30 powdered shake products were analyzed: 23 protein mixes and 7 botanical mixes. The protein sources consisted of whey, pea, hemp, sprouted brown rice, egg albumin, rice, milk casein, soy, and whey. The various botanical mixes contained wheat, barley, oat and kamut grasses; alfalfa; fruit, vegetable, and various plant extracts and powders; coconut seeds; spirulina; apple fiber; sprouted barley malt; and whole leaf wheat grass powder.

Sample Preparation

All sample preparation was performed in laminar flow hoods known to be free of contamination from trace metals. In the first round of analyses, 10 protein and 5 botanical shake powder products were pooled in 5 pools (3 per group) in quantities proportional to their respective serving sizes and screened for As, Cd, Cr, and Pb by inductively coupled plasma dynamic reaction cell mass spectrometry (ICP-DRC-MS). Pool 4 was found to contain elevated levels of As and Cd, according to recommended limits set forth by federal and state regulatory agencies as detailed in the Maximum Recommended Thresholds section; Pb levels were not obtained for that pool. In the second round of analyses, the three samples from Pool 4 and an additional 15 new shake mix samples were analyzed individually for As, Cd, Cr, and Pb by ICP-DRC-MS.

Sample Analysis

Applied Speciation and Consulting, LLC, performed all ICP-DRC-MS analyses. Briefly, all water used for dilutions and sample preservatives were monitored for contamination to account for any biases associated with the sample results. A known mass of each sample was weighed into a polypropylene vial. All samples were then digested with aliquots of concentrated HNO_3 and H_2O_2 in a hot block apparatus, in accordance with U.S. Environmental Protection Agency (U.S. EPA) Method 3050B. All sample analyses were preceded by a minimum of a 5-point calibration curve spanning the entire concentration range of interest. All calibration curves associated with each analyte of interest were standardized by linear regression, resulting in a response factor. All sample results were instrument-blank corrected to account for

TABLE 2

Arsenic (As), Cadmium (Cd), Chromium (Cr), and Lead (Pb) Levels in 18 Individual, Commercially Available Protein and Botanical Shake Mix Powders

Shake Type	Main Ingredients	Product #	ppm (µg/g)				Serving Size (g)	µg/Single Serving				µg/Three Servings			
			As	Cd	Cr	Pb		As	Cd	Cr	Pb	As	Cd	Cr	Pb
Protein	Milk casein	1	0.021	0.008	0.157	0.013	60	1.26	0.48	9.42	0.78	3.78	1.44	28.26	2.34
	Pea, hemp, and brown rice proteins	2	0.058	0.170	3.250	0.094	35.9	2.08	6.10	116.68	3.37	6.25	18.31	350.03	10.12
	Sprouted brown rice and other sprouted grain proteins	3	0.113	1.100	0.743	0.402	22	2.49	24.20	16.35	8.84	7.46	72.60	49.04	26.53
	Sprouted brown rice protein	4	0.085	1.190	0.565	0.351	16	1.36	19.04	9.04	5.62	4.08	57.12	27.12	16.85
	Pea protein	5	0.111	0.044	6.100	0.141	40	4.44	1.76	244.00	5.64	13.32	5.28	732.00	16.92
	Whey	6	0.032	0.009	2.060	0.013	35	1.12	0.32	72.10	0.46	3.36	0.95	216.30	1.37
	Rice protein	7	0.150	1.300	0.260	2.300	15	2.25	19.50	3.90	34.50	6.75	58.50	11.70	103.50
	Sprouted brown rice and other sprouted grain proteins	8	0.130	0.750	0.370	3.700	79	10.27	59.25	29.23	292.30	30.81	177.75	87.69	876.90
	Sprouted brown rice and flax seeds	9	0.150	0.190	0.160	4.800	45	6.75	8.55	7.20	216.00	20.25	25.65	21.60	648.00
	Pea, hemp, and brown rice proteins	10	0.024	0.186	0.148	0.017	22.2	0.53	4.13	3.29	0.38	1.60	12.39	9.86	1.13
	Whey	11	0.033	0.019	0.369	0.015	45	1.49	0.86	16.61	0.68	4.46	2.57	49.82	2.03
	Pea and hemp proteins, berries fruits, vegetables	12	0.046	0.036	0.115	0.027	61	2.81	2.20	7.02	1.65	8.42	6.59	21.05	4.94
	Soy protein	13	0.013	0.033	0.773	0.009	25	0.33	0.83	19.33	0.23	0.98	2.48	57.98	0.68
	Whey	14	0.006	0.001	0.013	0.002	21.5	0.13	0.02	0.28	0.04	0.39	0.06	0.84	0.13

continued ▶

any operational biases. Prior to sample analysis, all calibration curves were verified using second-source standards that are identified as initial calibration verification standards. Ongoing instrument performance was monitored by the analysis of continuing calibration verification standards and continuing calibration blanks at a minimal interval of every 10 analytical runs.

The sample digests were analyzed using ICP-DRC-MS. An aliquot of each sample digest was introduced into radio frequency plasma where energy-transfer processes cause

desolvation, atomization, and ionization. The ions were extracted from the plasma through a differentially pumped vacuum interface and travel through a pressurized chamber containing a specific reactive gas that preferentially reacts with either interfering ions of the same target mass to charge ratios (m/z) or with the target analyte, producing an entirely different m/z , which can then be differentiated from the initial interferences. A solid-state detector detected ions transmitted through the mass analyzer and the resulting current was processed by a data handling system. In accor-

dance with many promulgated methods (e.g., U.S. EPA methods), the instrument is set up to collect three replicate measurements or readings for each analyte; the result that is reported for each analyte for each sample is the average of three replicate measurements.

Maximum Recommended Thresholds

Currently, there are no federal guidelines with set limits for metal contamination in dietary supplements. Several agencies at the state, federal, and international levels, however, have issued recommendations on esti-

TABLE 2 *continued***Arsenic (As), Cadmium (Cd), Chromium (Cr), and Lead (Pb) Levels in 18 Individual, Commercially Available Protein and Botanical Shake Mix Powders**

Shake Type	Main Ingredients	Product #	ppm (µg/g)				Serving Size (g)	µg/Single Serving				µg/Three Servings			
			As	Cd	Cr	Pb		As	Cd	Cr	Pb	As	Cd	Cr	Pb
Botanical	Spirulina; wheat, barley, kamut, and oat grasses; various fruit and vegetable powders; herbal extracts	15	2.390	0.139	9.130	0.108	12.1	28.92	1.68	110.47	1.31	86.76	5.05	331.42	3.92
	Barley, alfalfa, oat, wheat, and kamut grasses; fruit and vegetable desiccated juices	16	0.332	0.163	18.000	0.184	10	3.32	1.63	180.00	1.84	9.96	4.89	540.00	5.52
	Coconut seeds, various plant extracts	17	0.026	0.015	0.228	0.085	18	0.47	0.27	4.10	1.53	1.40	0.81	12.31	4.59
	Barley, wheat, alfalfa and oat grass; spirulina	18	0.182	0.070	0.681	0.464	8	1.46	0.56	5.45	3.71	4.37	1.68	16.34	11.14

Note. Bolded values represent amounts in excess of recommended daily maximum limits: As, 10 µg; Cd, 4.1 µg; Cr, 150 µg; and Pb, 20 µg.

mated safe maximum daily exposures for As, Cd, Cr, and Pb for adults, as outlined below.

As: U.S. EPA limits total As intake to 10 µg/day (in 1 L of drinking water), including the inorganic and the less toxic organic forms (U.S. EPA, 2017). California Proposition 65 requires a warning on labels for a daily serving in excess of 10 µg inorganic As (Office of Environmental Health Hazard Assessment [OEHHA], 2002, 2016a, 2016b). The American National Standards Institute (ANSI)/National Sanitation Foundation (NSF) International's International Dietary Supplement Standard #173 recommends a maximum of 10 µg/day of As (NSF International, 2006). The Food and Agricultural Organization/World Health Organization (FAO/WHO) Joint Expert Committee on Food Additives considers acceptable daily intakes of 15 µg of As for a 70 kg adult (European Environment and Health Information System [ENHIS], 2009). USP, which makes recommendations on dietary supplements, also suggests a limit of 15 µg of As per daily serving (USP, 2016).

Cd: U.S. EPA (2017) and California's Proposition 65 (OEHHA, 2002) both recommend a limit of 4.1 µg/day of Cd from all sources, whereas USP sets the maximum at 5 µg/day (USP, 2016). The European Food Safety Authority (EFSA) sets a limit of 25 µg/day for a 150 lb adult (EFSA Panel, 2011).

Cr: U.S. EPA and California's Proposition 65 (OEHHA, 2002) both state a limit of total elemental Cr at 150 µg/day. As the reciprocal interconversion between Cr(VI) and Cr(III) species is well documented during the analytical process (Wolf, Morman, Hageman, Hoefen, & Plumlee, 2011), we measured total Cr levels. We note that although the analysis by analytical mass spectrometry is designed to minimize Cr species interconversion, it cannot prevent oxidation of Cr(III) to Cr(VI) or reduction of Cr(VI) to Cr(III) in all matrixes. A suite of quality controls can be performed to monitor for these species conversions, but cannot guarantee acceptable matrix spike recoveries. Therefore, here we report levels of total Cr and apply the recommended maximum daily

doses for total Cr as the safe threshold in the interpretation of our data.

Pb: California Proposition 65 states that children should not be exposed daily to more than 6 µg, pregnant women to 25 µg, and all other adults to 70 µg of Pb because of its developmental neurotoxic effects (OEHHA, 2002). More conservatively, ANSI states that dietary supplements should not contain undeclared metals that would cause an intake of greater than 20 µg/day (NSF International, 2006). In contrast, FAO/WHO considers acceptable daily intakes of 250 µg/day (ENHIS, 2009).

In consideration of the variability of perceived safe limits, and that shake mixes are consumed by the general public including susceptible populations such as children, young adults, pregnant women, and the sick and elderly, we considered the lowest levels recommended by any agency for adults as the maximum daily permissible exposure in our interpretation of the data. Accordingly, the thresholds used in this study were As, 10 µg; Cd, 4.1 µg; Cr, 150 µg; and Pb, 20 µg.

Results and Discussion

The mass spectrometry screening of the pooled shake powders revealed levels of As (9.93 μg) and Cd (5.17 μg) approaching or modestly exceeding the limit for one serving size in Pool 4 from the five pooled samples analyzed (Table 1). Therefore, we went on to individually analyze the three powdered mixes from Pool 4, along with 15 additional shake mix samples, for As, Cd, Cr, and Pb, using ICP-DRC-MS. Results of this analysis are presented in Table 2, which include the product serving size and total amount of each metal per serving for both a single serving and for three servings for each of the shake mix powders tested.

Our analysis revealed that for a single daily serving, there were elevated levels of one or several heavy metals in 10 of the 18 products that were individually tested (Table 2). Specifically, there were elevated levels in single servings (indicated in bold in Table 2) for As in one protein and one botanical shake mix (10.27 μg and 28.92 μg in products 8 and 15, respectively); elevated Cd in seven protein mixes (6.10 μg , 24.20 μg , 19.04 μg , 19.50 μg , 59.25 μg , 8.55 μg , and 4.13 μg in products 2, 3, 4, 7, 8, 9, and 10, respectively); elevated total Cr in one protein shake (244.00 μg in product 5) and one botanical mix (180.00 μg in product 16); and elevated Pb levels in three protein shakes (34.50 μg , 292.30 μg , and 216.00 μg in products 7, 8, and 9, respectively). Of note, a single serving of product 8, comprised of sprouted brown rice and other sprouted grain proteins, was high in three of the four metals.

As it is not uncommon for some individuals to consume shakes multiple times daily as meal replacements or because they consider these products as “healthy” additions to their diets, the ingested levels of these heavy metals from multiple servings could be far in excess of the suggested daily maximum levels. When considering consumption of three servings per day as was reported in the *Consumer Reports* (2010) study, 11 of the 18 products exceeded the daily “safe” threshold for at least one heavy metal. Three daily servings of the most contaminated mix, Product 8, would far exceed “safe” levels of all four heavy metals, containing 30.81 μg As, 177.75 μg Cd, 87.69 μg Cr, and 876.90 μg Pb.

We also observed that protein mixes had higher heavy metal levels than botanical mixes, particularly rice-based protein shake mixes, which had the most heavy metal con-

tamination of all mixes. On the other hand, for one daily serving, no whey-based protein mixes had heavy metals that exceeded the threshold daily limits, and for three daily servings only one whey mix exceeded the threshold limits for total Cr (216.30 μg).

Arsenic is ubiquitous in the environment, introduced from anthropogenic and natural sources. Inorganic As is a well-known cause of skin, lung, and bladder cancers, and possibly liver, kidney, and prostate (WHO, 2012). It is also associated with skin lesions, diabetes, cardiovascular disease (Hughes, Beck, Chen, Lewis, & Thomas, 2011), and immunotoxicity (Dangleben, Skibola, & Smith, 2013). Some organic forms also might have toxic and potentially carcinogenic properties (Carlin et al, 2016; Ishi & Tamaoka, 2015). Maternal exposure to As might be detrimental to the fetus (Lai, Cottingham, Steinmaus, Karagas, & Miller, 2015), as it readily passes through the placenta.

Significant sources of chronic exposure to inorganic As are through consumption of contaminated drinking water and rice (Wilson, 2015). Due to findings of inorganic As in infant rice cereals, the Food and Drug Administration (FDA) has proposed a limit or “action level” of 100 ppb for inorganic arsenic in infant rice cereal (FDA, 2016). Although we tested several rice-based protein mixes, only one exceeded maximum levels of As at 10.27 μg /serving. We found higher levels of As, however, in product 15 (28.92 μg /serving), a botanical shake mix that contains spirulina and grasses of wheat, barley, and oats as the major ingredients. A previous study of As contamination in dietary supplements found that spirulina contained low levels of inorganic As (Hedegaard, Rokkjaer, & Sloth, 2013), which may explain the presence of As in product 15. We cannot rule out the possibility that As-contaminated wheat, barley, or oat grasses contributed to the high levels of As that were found in this shake mix product.

Cd, a rare but widely dispersed element, is found naturally in the environment. In addition to its classification by IARC as a Group 1 carcinogen for lung, kidney, and prostate cancers (WHO, 2012), large meta-analyses also highlight a potential role in breast cancer risk (Lin, Zhang, & Lei, 2016). Anthropogenic sources such as mine/smelter wastes, commercial phosphate fertilizers, sewage sludge, and municipal waste landfills contribute to high levels of Cd found in soil (Ostrowski et

al., 1999). Cd readily enters the food chain from contaminated soil or water through uptake by plants due to its high phytoaccumulation index (Shahid, Dumat, Khalid, Niazi, & Antunes, 2017). Cd levels are particularly high in tobacco, rice, other cereal grains, potatoes, and vegetables, and therefore can lead to significant dietary exposures. In the present study, we found that every shake mix that contained rice protein was high in Cd, with levels ranging from 6.1–59.25 μg /serving, a level that far exceeds the USP threshold for drugs and dietary supplements, as well as all other agency thresholds.

Cr(VI) is a known respiratory carcinogen of the lung in humans (WHO, 1990). Oral Cr(VI) is also carcinogenic in animals and humans. Although the effects of oral Cr(VI) are mitigated by its reduction in the gut, a portion evades detoxification, reaches target tissues, and enter cells (Sun et al., 2015). Several mechanisms have been outlined in Cr(VI) carcinogenesis including its intracellular reduction to Cr(III) that might interact with DNA to yield genotoxic and mutagenic effects, Cr(VI)-induced inflammation and oxidative stress, and effects on cell survival signaling (Nickens, Patierno, & Ceryak, 2010). Increased industrial applications have led to large amounts of Cr(VI) released into soil, groundwater, and air, where it is taken up and accumulated in various plants and crops (Shanker, Cervantes, Loza-Tavera, & Avudainayagam, 2005; Suvarapu & Baek, 2016). We found 244.00 μg of Cr/serving in one pea protein shake mix and 180.00 μg /serving in one botanical mix that contained barley, alfalfa, oat, wheat, and kamut grasses, and various fruit and vegetable extracts/powders. As with As and Cd, the source of Cr in these products might be through environmental contamination.

Pb exposure is associated with risk of renal tumors, reduced cognitive development, hypertension, and cardiovascular disease in adults. Children appear to be especially sensitive to Pb; exposure is linked to decreased IQ and poor learning. Pb absorption in the gut can be as much as 5–10 times greater in young children than in adults (Alexander, 1974; Chamberlain & Brown, 1978; James, Hilburn, & Blair, 1985; Ziegler, Edwards, Jensen, Mahaffey, & Fomon, 1978). It can cross the placenta and reach the fetus; thus, maternal Pb exposures are highly relevant. Through uptake from Pb in soil or atmospheric depo-

sition, Pb can accumulate in leafy vegetables and crops including rice (Mushak, Davis, Crocetti, & Grant, 1989). While we did not identify high levels of Pb in any botanical-based shake mixes, or in any whey or casein protein shake powders, several of the rice protein shake products contained high levels of Pb. In fact, we found high Pb levels only when rice was present in the product. We cannot rule out, however, that the cans or food processing methods used by some of these manufacturers could at least be one additional source of Pb in the shake mixes where high lead levels were found.

Conclusion

In summary, we found that for a single daily serving, 56% of the shake mixes tested contained elevated levels of at least one toxic heavy metal. Most compelling was that several rice protein-based shake powders were high in Cd and Pb, while whey protein-based mixes had the lowest heavy metal burden. The likely source of these toxic heavy metals is through their uptake in plants through contaminated water and/or soil.

One of the consequences of globalization has been the lack of transparency by the dietary supplement industry regarding the origin of food and nonfood ingredients in dietary and nutritional supplements. There is no way for the consumer to know how the crops, veg-

etables, and plants used in these products are grown, harvested, and processed—what, if any, quality control parameters are in place to ensure product purity and safety for human consumption. Depending on where specific food ingredients originate, crops might be planted in contaminated soil or irrigated with contaminated water, even if they are labeled as organic. Extracts that are found in many functional foods might be extracted with toxic solvents or through processes that introduce toxic chemicals into the final product. The consumer relies on the manufacturers to supply high quality, effective, and safe products; however, industry self-regulation does not guarantee the delivery of high-quality, uncontaminated products.

The public health impact of consumption of heavy-metal contaminated dietary supplements, including shake mix powders and other functional foods and beverages, is unknown and hard to quantify. Toxic heavy metals can accumulate in the body over time and cause irreparable damage in humans, particularly in highly susceptible populations such as pregnant women and their unborn children, young children, teens, and the sick and elderly. As these products are marketed as health food, many people believe that they are natural and safe and will not produce adverse health effects.

This study emphasizes the need for consumers to better understand the dietary sources of

toxic heavy metals and subsequently how to reduce consumption to safe levels. Manufacturers should also take an active role in mitigating the risk to the public by testing, identifying, and removing heavy metals from their shake mixes, and publishing peer-reviewed data that support the healthfulness of their products. Future studies are warranted that include a more thorough investigation of the raw ingredients found in shake mixes in an effort to identify the sources and the mechanisms of contamination, whether through environmental contamination, poor manufacturing practices, or other modes. Ultimately, further studies may lead to the development of stricter voluntary or regulatory policies in efforts to enhance consumer protection. 🐼

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Corresponding Author: Christine F. Skibola, Department of Hematology and Medical Oncology, Winship Cancer Institute, Emory University School of Medicine, 1365 Clifton Road NE, Building B, Suite 4300-B, Atlanta, GA 30322. E-mail: christine.skibola@emory.edu.

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Certified Food Safety Manager Impact on Food Inspection Citations

Jovan Harris, MPH, PhD
Walden University

Abstract The literature has been inconclusive concerning the connection between food safety manager certification and the incidence of critical food safety violations. An analysis of 2013 data from 1,547 restaurants in North, Central, and South Georgia health districts examined the relationship between the presence or absence of a certified food safety manager (CFSM) and the number of risk factors cited on food inspection reports and the food safety score. In addition, the study examined whether operation type (i.e., chain versus independently owned) had an impact on the number of risk factors and food safety score. Using a two-tailed independent-samples *t*-test revealed restaurants with a CFSM had significantly more risk factors cited on food safety inspections and lower food safety scores than restaurants without a CFSM. There was also a significant difference among chain and independent restaurants. Chain restaurants had fewer risk factors cited on restaurant inspections and had higher food safety scores.

Introduction

In the U.S., a significant source of foodborne illness comes from food prepared outside the home. Annually, there are estimated to be 76 million cases of foodborne illnesses in the U.S., which include 325,000 hospitalizations and 5,000 deaths (Mead et al., 1999). Sixty-five percent of foodborne illness outbreaks in U.S. restaurants were linked to infected restaurant employees, who can directly transmit pathogens that cause foodborne illness in consumers (Mead et al., 1999). Several factors have an impact on food safety in food service establishments: a) inspections conducted by local or state inspectors, b) knowledge of the Food and Drug Administration (FDA) *Food Code*, and c) proper training of managers and food workers (Bryan, 2002; FDA, 2009).

In the U.S., regulatory agencies such as local, county, and state health departments

conduct health inspections of food handling facilities. The primary objective of health inspections is the prevention of foodborne illness. This objective is accomplished by control measures such as demonstrating knowledge (e.g., compliance with code, presence of a certified food safety manager [CFSM], food safety questions answered correctly), implementing employee health policies, identifying vehicles of contamination, monitoring of time/temperature relationships, and issuing consumer advisories (U.S. Department of Health and Human Services, 2009).

Health inspectors perform inspections at restaurants to ensure that restaurants are in compliance with health and sanitation regulations designed to ensure consumer and food employee safety; however, food safety inspections alone have not been effective in decreasing critical violations (Cruz, Katz, & Suarez, 2001; Jones, Pavlin, LaFleur, Ingram,

& Schaffner, 2004; Newbold, McKeary, Hart, & Hall, 2008; Phillips, Elledge, Basara, Lynch, & Boatright, 2006). Food service workers are taught how to safely prepare and handle food; not being properly trained on food safety can lead to food being mishandled, which can increase risk factors of foodborne illness (Wotecki & Kineman, 2003).

Proper training in food safety of managers and food workers is significant because the costs associated with foodborne illness result in an estimated \$7.7–\$23 billion impact annually for consumers, the food industry, and the economy (Council for Agricultural Science and Technology, 1994). Managers who have positive attitudes and view food safety practices as important are more likely to promote food safety practices among workers (Mortlock, Peters, & Griffith, 2000). Restaurants face many challenges in trying to prevent foodborne illness outbreaks, such as employees not being adequately trained in food handling and high turnover rates (Jones & Angulo, 2006). Therefore, CFSMs play a significant role and have the essential duty to ensure that food workers are properly trained in food safety practices that reduce the risk of foodborne illness (Cates et al., 2009).

Using the FDA *Food Code* as a reference, Georgia implemented rules and regulations on food safety and developed inspection forms and scoring standards. The state of Georgia mandates that all restaurants have at least one CFSM (Georgia Department of Public Health, n.d.). Even though establishments are in compliance by having a CFSM, the violations cited on inspection reports show that employees are not being trained effectively (Hammond, Brooks, Schlottmann, Johnson, & Johnson, 2005). With a CFSM, risk factors that are known to cause foodborne illness should be decreased. Con-

TABLE 1

Descriptive Statistics for Independent Variables (N = 1,547)

Variable	n	%
Presence of a certified food safety manager		
No	178	11.5
Yes	1,369	88.5
Type of restaurant		
Independent	860	55.6
Chain	687	44.4

TABLE 2

Descriptive Statistics for Dependent Variables (N = 1,547)

Variable	Minimum	Maximum	Mean	SD
Number of risk factors	0	5	1.18	0.67
Food safety scores	41	97	85.65	7.60

SD = standard deviation.

control measures should be in place that prevent outbreaks or at least reduce the occurrence of foodborne illness in all facilities (Cates et al., 2009). Analyzing inspection reports by examining the violations gives a clear understanding of whether these control measures are working to mitigate risk factors known to cause foodborne illness (Jones et al., 2004).

The purpose of this quantitative study was to examine a) the relationship between having a CFSM and the number of risk factors cited on restaurant inspections in Georgia; b) whether restaurant operation type (i.e., chain versus independent restaurant) has an impact on the number of risk factors cited on restaurant inspections; c) the relationship between having a CFSM and the restaurant food safety score identified on restaurant inspections; and d) whether or not restaurant operation type (i.e., chain versus independent restaurant) has an impact on the restaurant food safety score. Cates and coauthors (2009) looked at the effectiveness of food safety training and certification in restaurants located in Iowa and found certain risk factors can be controlled by having a certified kitchen manager—but that training and certification must be kept current to have a positive influence on reducing risk factors. Education

is important, but also must address other factors that can have an impact on safe food handling practices, such as management and environmental constraints.

Methodology

Setting and Sample

The setting for this study was the state of Georgia. The sample included health inspections from restaurants located in North, Central, and South Georgia health districts. Only routine health inspections and Risk Type 2 facilities were included in the study. Risk Type 2 facilities are associated with food handling practices that can lead to a foodborne illness outbreak. A restaurant that had 10 or more units was categorized as a chain, and any restaurant that was not part of a chain was considered independent. Bars, institutions, and schools were excluded from this study.

Instrumentation and Materials

The data for this study were accessed through each health district's website. Each district website contained a link to view restaurant scores and violations cited. Health inspectors recorded critical and noncritical violations during routine inspections on food service

inspection reports. The report has three sections. The first section contains information about the restaurant, such as name of establishment, date, risk type, and purpose of inspection. The second section contains citations based on *Georgia Food Rules and Regulations* (Georgia Department of Public Health, n.d.); depending on their potential to cause an imminent health hazard, violations are categorized as foodborne illness risk factors, public health interventions, or good retail practices. Violations cited under foodborne illness risk factors and public health interventions have a greater potential to cause a foodborne illness. The third section contains an area to record temperatures, document violations, and note corrective actions.

Data Collection and Analysis

To obtain health inspection reports, each health district website was accessed to query restaurants. Restaurants were sorted by the absence or presence of a CFSM, chain versus independently owned restaurant, and the number of critical violations (defined as poor personal hygiene, contamination with potentially hazardous pathogens, failure to maintain proper temperature, and insufficient time/temperature control) identified on restaurant food inspections reports. A two-tailed independent samples *t*-test was conducted. The number of risk factors cited during restaurant inspections and the restaurant food safety score identified on restaurant inspections were the dependent variables, and the presence of a CFSM (yes versus no) and the type of restaurant (chain versus independent) was the between-subject's independent variable. The data were entered into SPSS. All statistical tests were conducted at $\alpha = .05$.

Results

Data for a total of 1,547 restaurants were available for this study, including 647 (41.8%) from Central Georgia, 375 (24.2%) from Southern Georgia, and 525 (33.9%) from Northern Georgia. The majority of the restaurants (88.5%) had a CFSM, and most (55.6%) were independent restaurants (Table 1). The number of risk factors identified in the restaurant inspections ranged from 0–5 (mean = 1.18 (standard deviation [*SD*] = 0.67)). The food safety scores ranged from 41–97 (mean = 85.65, *SD* = 7.60) (Table 2).

The independent-samples *t*-test was statistically significant, $t(199) = -13.46, p < .001$ (Table 3) comparing restaurants with a CFSM to restaurants without a CFSM with the number of risk factors cited during restaurant inspections. Specifically, the means in Table 3 show that restaurants with a CFSM tended to have more risk factors (mean = 1.28, *SD* = 0.58) than restaurants without a CFSM (mean = 0.41, *SD* = 0.84). Furthermore, there was a statistically significant difference, $t(1544) = 2.62, p = .009$, between major restaurant chains and independent restaurants on the number of risk factors cited during restaurant inspections. Independent restaurants tended to have a higher number of risk factors (mean = 1.22, *SD* = 0.73) than chain restaurants (mean = 1.13, *SD* = 0.60).

Restaurants without a CFSM had significantly higher food safety scores (mean = 87.08, *SD* = 10.12) than restaurants with a CFSM (mean = 85.46, *SD* = 7.19) (Table 4). The *t*-test was statistically significant, $t(201) = 2.07, p = .040$, between restaurants that had a CFSM and restaurants that did not have a CFSM on the restaurant food safety score identified on restaurant inspections (Table 4). Among chain and independent restaurants, we also saw a statistically significant difference, $t(1540) = -4.25, p < .001$.

It was of interest to determine the extent to which the results from the previous analyses would vary if the district for each restaurant was taken into account. Therefore, a series of factorial analysis of variance (ANOVAs) was performed similar to the first set of analyses, but including district as a second independent variable in each analysis. Table 5 shows the means that were compared in the subsequent analyses. Table 6 shows the results between restaurants that have a CFSM and restaurants that do not have a CFSM from the three districts on the number of risk factors. The main effect for district was not statistically significant, $F(2, 1541) = 1.25, p = .286$ (Table 6). This finding indicated that overall the number of risk factors did not differ significantly between Central, South, and North districts. The main effect for presence of a CFSM, however, was statistically significant, $F(1, 1541) = 315.30, p < .001$ (Table 6). The interaction between district and presence of a CFSM was also statistically significant, $F(2, 1541) = 4.70, p = .009$ (Table 6). This finding indicated that the difference between restau-

TABLE 3

Results From Independent-Samples *t*-Test Comparing Restaurants With and Without a Certified Food Safety Manager (CFSM) in Terms of the Number of Risk Factors (*N* = 1,547)

Group	Mean	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p</i> -Value
Without a CFSM	0.41	0.84	-13.46	199	<.001
With a CFSM	1.28	0.58			

SD = standard deviation; *df* = degrees of freedom.

TABLE 4

Results From Independent-Samples *t*-Test Comparing Restaurants With and Without a Certified Food Safety Manager (CFSM) in Terms of Food Safety Scores (*N* = 1,547)

Group	Mean	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p</i> -Value
With a CFSM	87.08	10.12	2.07	201	.040
Without a CFSM	85.46	7.19			

SD = standard deviation; *df* = degrees of freedom.

rants with a CFSM and restaurants without a CFSM varied for the three districts.

The differences between major restaurant chains and independent restaurants from the three districts on the number of risk factors show the main effect for district was statistically significant, $F(2, 1541) = 9.84, p < .001$. This finding differed from the results of the prior ANOVA, where the main effect for district was not statistically significant. In the results shown in Table 5, the statistically significant main effect for district indicated that the number of risk factors was somewhat lower for the Central district (mean = 1.14, *SD* = 0.60) and the North district (mean = 1.15, *SD* = 0.65) when compared with the South district (mean = 1.31, *SD* = 0.79). The main effect for the type of restaurant was also statistically significant, $F(1, 1541) = 4.06, p = .044$; however, the interaction between district and type of restaurant was not statistically significant, $F(2, 1541) = 2.75, p = .065$.

In the analysis performed to determine if there was a statistically significant difference between restaurants that have a CFSM and restaurants that do not have a CFSM from the

three districts on the restaurant food safety score identified on restaurant inspections, the main effect for district was not statistically significant—indicating that the food safety scores for restaurants from the three regions did not differ, $F(2, 1541) = 1.96, p = .141$. On the other hand, the main effect for presence of a CFSM was statistically significant, $F(1, 1541) = 7.43, p = .006$. Still, the interaction between district and presence of a CFSM was not statistically significant, $F(2, 1541) = 0.36, p = .700$.

The main effect for district between major restaurant chains and independent restaurants in the restaurant food safety score was statistically significant, $F(2, 1541) = 8.81, p < .001$. This finding indicated that the mean food safety scores were highest for the Central district (mean = 86.40, *SD* = 7.41), followed by the North district (mean = 85.70, *SD* = 6.45), with scores in the South district being the lowest (mean = 84.28, *SD* = 9.09) (Table 5). The main effect for type of restaurant was also statistically significant, $F(1, 1541) = 14.28, p < .001$. The interaction between district and type of restaurant, however, was not statistically significant, $F(2, 1541) = 0.27, p = .766$.

TABLE 5

Mean Number of Risk Factors and Food Safety Scores as a Function of District, Having a Certified Food Safety Manager (CFSM), and Type of Restaurant (N = 1,547)

	Central District		South District		North District	
	Mean	SD	Mean	SD	Mean	SD
Number of risk factors	1.14	0.60	1.31	0.79	1.15	0.65
Presence of a CFSM						
No	0.36	0.68	0.32	0.84	0.53	1.00
Yes	1.24	0.50	1.42	0.71	1.23	0.54
Type of restaurant						
Independent	1.21	0.63	1.29	0.84	1.20	0.73
Chain	1.07	0.57	1.34	0.73	1.06	0.46
Food safety scores	86.40	7.41	84.28	9.09	85.70	6.45
Presence of a CFSM						
No	87.37	9.94	86.47	12.14	87.10	9.07
Yes	86.27	6.99	84.04	8.67	85.51	6.00
Type of restaurant						
Independent	85.64	8.28	83.78	10.12	85.02	7.20
Chain	87.11	6.43	84.93	7.57	86.92	4.58

SD = standard deviation.

TABLE 6

Results From Factorial ANOVA With Number of Risk Factors as the Dependent Variable and District and Presence of a Certified Food Safety Manager (CFSM) as the Independent Variables (N = 1,547)

Effect	Sum of Squares	df	Mean Squares	F	p-Value
District	0.92	2	0.46	1.25	.286
Presence of a CFSM	116.44	1	116.44	315.30	<.001
District by presence of a CFSM	3.47	2	1.73	4.70	.009
Error	569.10	1,541	0.37		

ANOVA = analysis of variance; df = degrees of freedom.

Discussion

Managers are certified in food safety and have been educated about the relationship between risk factors that lead to foodborne illnesses and food safety practices. Several studies have examined the relationship among certified managers, risk factors, and restaurant scores and found that scores and the number of risk factors improved with the presence of a

CFSM (Cates et al., 2009; Cotterchio, Gunn, Coffill, Tormey, & Barry, 1998; Hedberg et al., 2006). In a study conducted by Mathias and coauthors (1994), there was no significant association between violations cited on food safety inspections and food safety training. The findings from this current study showed a statistically significant difference between restaurants with a CFSM and restaurants without

a CFSM. Results revealed that restaurants that had a CFSM had more risk factors than restaurants without a CFSM. Likewise, Kassa and coauthors (2010) found that certification did not impact the number of violations cited on food inspection reports. Also, restaurants with a CFSM had lower food safety scores than restaurants without a CFSM.

Moreover, Cates and coauthors (2009) revealed in their study that certified managers were less likely to have a critical violation; however, certified managers were not effective at controlling temperature and time violations, such as those related to proper cooling, cooking, and reheating temperatures, which are risk factors associated with foodborne illness. It is possible that managers are being certified but are not implementing the tools and food safety practices learned in food safety training among employees to break the chain of transmission by correcting unsafe food practices. In some cases, managers might not feel that food safety is important. When managers are dealing with turnovers and inadequately trained employees, food safety might not be a top priority (Enz, 2004). This lack of implementation and motivation could lead to food being mishandled, which increases the chance for critical violations.

Another possibility is that managers of independent restaurants view food safety as more important, due to the fact that they work in small businesses (sometimes family owned) that they value. In most independent restaurants, the staff is very small and often consists of family, with all working toward a common goal. Cates and coauthors (2009) suggested that the size of the establishment could affect the number of critical violations. Larger establishments, when compared with smaller establishments, are more likely to be cited for critical violations. This finding could be due to the fact that larger establishments have a larger volume of customers than smaller establishments do, increasing the chance for more critical violations.

There was a statistically significant difference between chain restaurants and independent restaurants for risk factors and food safety scores. Analyses showed that chain restaurants had fewer risk factors and higher food safety scores than independent restaurants. Murphy and coauthors (2011) examined the association between manager food safety certification

and inspection results among chain and independent restaurants and found results similar to those reported here. In a survey conducted by Roberts and Sneed (2003) on managers of independent restaurants in Iowa, researchers found that 43.2% of the managers of independent restaurants did not have guidelines for cleaning and sanitizing equipment, 24% did not have a hand-washing policy, and 46% had no measures for checking temperatures on food received. Kassa and coauthors (2010) suggested that restaurants that are considered chains usually have their own internal inspectors and corporate guidelines to follow that usually are more stringent than the rules and regulations of local health departments. In this study, it was found that food safety practices are being followed and implemented in chain restaurants more often than in independent restaurants, as evidenced by the number of risk factors identified. It is possible that chain restaurants have more support and available resources from a corporation than independent restaurants do, and that chain restaurants are more likely to have corporate support for food safety training.

Conclusions

There were several key findings. While restaurants with a CFSM had significantly more risk factors than restaurants without a CFSM, the number of risk factors for chain restaurants was significantly lower than that for independent restaurants. There was a significant difference between food safety scores for restaurants with a CFSM and restaurants without a CFSM. Restaurants with a CFSM had lower food safety scores than restaurants without a CFSM. For chain restaurants, there was also a significant difference in food safety scores on inspection reports compared with independent restaurants. Furthermore, the results from the previous analyses were confirmed in the supplemental ANOVAs performed. That is, even when district was included in the analysis, the results from the previous analyses held.

Food safety training and education are key components in the effort to minimize foodborne illness in restaurants. It is assumed that training and education have a significant effect on critical violations and foodborne illness outbreaks. Managers who

are certified in food safety are perceived to be more knowledgeable in food safety practices and have the skills to implement prevention measures to ensure that food safety measures are being met. Managers have the responsibility of ensuring food safety in their operation: it is important they make sure workers are trained in food safety, are retrained in food safety regularly, and are monitored to make sure procedures are being followed. The literature has been inconclusive in regard to the effectiveness of manager training, however, in preventing or decreasing critical violations. Exploring the effectiveness of manager certification is an important aspect to learn more about for food safety and the protection of public health, and further research is needed. 🐾

Corresponding Author: Jovan Toccara Harris, Walden University, 2516 Whispering Pines Road, Albany, GA 31707.
E-mail: Toccara21@yahoo.com.

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Microbial Quality of Ice Machines and Relationship to Facility Inspections in the Toledo, Ohio, Area

Hailu Kassa, MSOH, MPH, PhD
Bowling Green State University

Brian Harrington, MPH, PhD
University of Toledo

Karim Baroudi, MPH, RS, REHS
Hancock Public Health

Gary S. Silverman, D Env, RS
University of North Carolina at Charlotte

Abstract Ice might contribute meaningfully to foodborne illness. Ice machines and ice scoops can be contaminated by microbial pathogens, resulting in people consuming contaminated ice. Typical of most states within the U.S., in Ohio assessments of ice machines and related equipment are part of mandated food service facility inspections by local health agencies. These visual inspections, however, might provide insufficient protection from microbial contamination. To explore the potential for disease transmission, we conducted microbiological surveys of ice throughout the Toledo–Lucas County Health Department service area in Ohio.

We regularly found microbial contaminants, mostly nonpathogenic bacteria and fungi, within ice machines. The relative abundance of bacteria and fungi was significantly greater on the gaskets of ice machines than on ice machine bin walls or ice scoops. Microbial contamination of ice machines did not vary significantly by facility hazard potential class or inspection results.

The regular nature of microbial colonization of ice machines indicates that a meaningful potential exists for disease transmission. The nature of the colonization suggests that pathogenic contamination should not be present routinely, but rather occur sporadically. Management strategies could benefit from moving beyond visual inspection, to considering adoption of routine cleaning programs and implementing other barriers to microbial colonization.

Introduction

Foodborne illnesses are estimated as annually responsible for 3,000 deaths and 128,000 hospitalizations in the U.S., which constitutes a significant public health threat (Centers for Disease Control and Prevention [CDC], 2011.) The causative agents responsible for foodborne illnesses frequently are not identified, with the Centers for Disease Control and Prevention (CDC) reporting that overall only 44% of foodborne disease cases have a known

etiology. Of the cases for which the causative agents have been identified, norovirus was associated with 58% of the illnesses, and four bacteria species (*Salmonella* nontyphoidal, *Clostridium perfringens*, *Campylobacter* species, and *Staphylococcus aureus*) collectively were responsible for 33% of the illnesses. CDC further reported that the major types of foods associated with these illnesses were produce (46%), meat and poultry (22%), dairy and eggs (20%), and fish and shellfish (6.1%).

Health risks from contaminated ice rarely are reported, although evidence documented in the literature is sufficient to establish its potential for causing illness. For example, contaminated commercial ice has been implicated as a cause of Norwalk-like-viruses-related gastroenteritis on a cruise ship in Hawaii (Herwaldt et al., 1994). Another outbreak aboard a cruise ship was associated with consumption of ice contaminated by enterotoxigenic *E. coli* (ETEC). In that outbreak, water bunkered from Mexico or Guatemala was inadequately chlorinated and introduced ETEC into the ice machines (Koo et al, 2010).

Norovirus outbreaks have also been reported in several venues associated with ice. Contaminated water and ice from improperly set up and sanitized community dispensers caused an outbreak of norovirus gastroenteritis illness in a community in Arizona in 2004 (Reimus, Stratman, & Ludwig, 2004). Consumption of ice made from well water contaminated with sewage containing norovirus was responsible for an outbreak among football players during a game between the University of Pennsylvania and Cornell University in 1987 (Becker, Moe, Southwick, & MacCormack, 2000). Ice made using water contaminated with fecal material was a cause of norovirus outbreak in a resort town in Italy in 2002 (Boccia et al., 2002). Commercial ice made using environmentally contaminated water and/or inadequately treated water was a cause of diarrheagenic *E. coli* outbreak in a community in Brazil in 2004 (Falcão, Falcão, & Gomes, 2004). Ice contaminated with norovirus in restaurants provided further evidence of the potential for

TABLE 1

Reporting Protocol

Assigned Growth # (Relative Abundance)	Organism Growth Characteristic
0	Organism growth absent
1	Organism growth only in initial inoculum area
2	Organism growth in initial and second quadrants
3	Organism growth in first three quadrants
4	Organism growth in all quadrants

ice to be an important source of disease transmission (CDC, 2011).

Other studies not directly related to disease outbreaks show additional potential for contamination of ice that could lead to illness. A study at Taman University in Malaysia revealed the presence of fecal coliforms in about 36% of samples of ice cubes from 30 food service outlets (Mahat, Meor Ahmad, & Abdul Wahab, 2015). Mako and coauthors (2014) reported that 37% of their samples of ice bagged at retail sites and in ice from vending machines in Georgia contained an unsatisfactory level of coliform bacteria, and were significantly contaminated more frequently than ice cubes manufactured by companies monitored by the International Packaged Ice Association. Ice collected from retail points in Greece had large numbers of coliform and pathogenic strains of bacteria (Gerokomou et al, 2001). Another study reported that poor hygiene resulted in norovirus contamination of ice in hospital ice machines (Gebo et al, 2002). The viral load in the ice was considered large enough to cause illnesses in immune-compromised patients, but not in patients suffering from illnesses not related to immune suppression. Comparable results were found in other hospitals outside of the U.S. (Burnett, Weeks, & Harris 1994; Wilson, Hogg, & Barr, 1997).

Food service facilities regularly are licensed to operate following requirements established by each state, typically based on the Food and Drug Administration (FDA) *Food Code*. This code contains provisions related

TABLE 2

Identification Protocol for Bacteria

Type	Identification
Staph/micro	Gram-positive cocci; catalase positive; either singly, in clusters, or packets. Primarily would be staphylococci or micrococci.
G+ R spores (<i>Bacillus sp.</i>)	Gram-positive rods with endospores. Member of the genus <i>Bacillus</i> (and the newly created genera for aerobic endospore formers).
G+ R diphth/no spores	Gram-positive rods with diphtheroid morphology and no endospores.
G+ R branching	Gram-positive rods with branching. Member of the <i>Nocardia/Streptomyces</i> group.
<i>E. coli</i>	Identified by its characteristic growth on MacConkey agar, indole positive, cytochrome oxidase negative.
<i>Serratia marcescens</i>	Gram-negative enteric rod with characteristic red pigment (possibly one or two other <i>Serratia</i> spp. that have red pigmented colonies).
EGNR oxid -ve F lact +	Enteric gram-negative rod, oxidase negative, indole-negative fermenter of carbohydrates, lactose fermentation (on MacConkey agar) positive. Member of the Enterobacteriaceae family. Isolates encountered here have pink (slightly acidic) mucoid colonies on MacConkey agar and were most likely in the <i>Klebsiella/Enterobacter</i> group. These members of the Enterobacteriaceae, together with <i>E. coli</i> , are called coliforms.
EGNR oxid -ve F lact -ve	Enteric gram-negative rod, oxidase negative, no acid from lactose on MacConkey agar but fermenter of glucose in oxidation/fermentation (O/F) medium. Member of the Enterobacteriaceae family.
EGNR oxid -ve non-F	Enteric gram-negative rod, oxidase negative, no acid from lactose on MacConkey agar, no fermentation of glucose in O/F medium. Not a member of the Enterobacteriaceae family.
EGNR oxid + non-F	Enteric gram-negative rod, oxidase positive, no acid from lactose on MacConkey agar, no fermentation of glucose in O/F medium. Not a member of the Enterobacteriaceae family. Probably a pseudomonad or related genus.
<i>Pseudomonas aeruginosa</i>	Identified by its characteristic growth, pigment, colony appearance, and odor on TSA blood and MacConkey agars.

to the production and handling of ice at food service facilities. In Ohio, where this study was located, all food service facilities serving potentially hazardous foods—including ice—are required to obtain licenses. This requirement includes facilities in which ice is the only potentially hazardous food. In general, ice machine evaluations are limited to visual inspections, although such inspections might be inadequate for identifying the presence of pathogenic organisms (Kassa, Harrington, Bisesi, & Khuder, 2001).

Past work has established that ice machines have the potential for posing a significant risk of disease transmission, although ice machines have not been tested sufficiently to establish the magnitude of that risk. Our study explores this potential for risk through investigation of the microbial contamination of ice machines in food service facilities in the Toledo, Ohio, area. We also designed

this study to provide information potentially linking ice machine contamination with public health protection practices as documented by food service facility inspection records.

Materials and Methods

We sampled ice machines in licensed food service facilities in Toledo, Ohio, for a variety of bacteria and fungi during the summer and fall of 2013. Although not inclusive of all potential types of contaminants (e.g., viruses), this examination should provide potentially useful information revealing the scope of contaminated ice machines regulated by a typical food service licensing program.

Facility Selection

Facilities were selected through development of a study database drawing from the Toledo–Lucas County Health Department's (TLCHD) listing of 2,439 Risk Class 2, 3,

and 4 food service facilities, as facilities with these risk classes can legally handle unpackaged ice cubes for service to consumers. The classification of facilities into different licensing categories is based on the relative health risk they pose to public health, with the higher classification numbers signifying a higher level of risk (Ohio Administrative Code, n.d.).

The TLCHD database was exported into an Excel spreadsheet and subjected to a “research randomizer” to select a potential sampling pool of 150 license numbers. Facilities from this initial pool were excluded if they did not produce ice during our sample collection and/or walk-through inspection periods, if they had sealed ice making/dispensing systems, if they were permanently closed or changing their business plan before the end of the licensing period, if facility inspection reports were unclear, or if management was unwilling to participate. Based on these criteria, we included 115 facilities in this study.

Sampling Procedure

At each food service facility, we collected swab samples from an ice bin wall, the ice scoop, and from the ice machine door gasket. Two TLCHD registered sanitarians working in the Food Protection Unit and trained in the sampling protocol collected the samples used in this study. For each facility, a sample collection kit was provided consisting of three tubes, each containing two sterile swabs and a screw-capped tube containing 1 mL of sterile phosphate buffered saline (PBS). Swabs were held in a plastic cap for each swab tube and the registered sanitarians handled only that cap during sampling.

Immediately prior to sampling, the swabs were moistened (not made dripping wet) by being touched to the surface of the PBS. After each sample had been collected, the registered sanitarians returned the swabs to the tubes and labeled the tubes with the establishment’s health department license number and the area sampled (ice bin wall, ice scoop, or gasket.)

For the ice bin wall sample, an area of approximately 3 x 6 in. was swabbed below the normal level of the ice cubes. For the ice scoop sample, an area of approximately 3 x 6 in. was swabbed on the concave ice scoop surface. Areas were determined by visualizing a 3 x 6 in. sample area based on previous train-

TABLE 3
Number of Sites With Isolated Organisms by Facility Class and Location

	Class 2 Facilities (n = 20)			Class 3 Facilities (n = 53)			Class 4 Facilities (n = 42)			All Facilities (N = 115)		
	IW	SP	GT	IW	SP	GT	IW	SP	GT	IW	SP	GT
Yeast												
<i>Aureobasidium</i> sp.	4	1	11	5	3	10	6	1	11	15	5	32
<i>Aspergillus niger</i>	0	0	2	2	2	7	1	3	2	3	5	11
<i>Aspergillus</i> sp. (not niger)	1	2	2	3	2	10	0	1	1	4	5	13
<i>Penicillium</i> sp.	1	0	2	3	1	4	0	0	2	4	1	8
<i>Alternaria</i> sp.	4	1	4	6	7	14	7	2	12	17	10	30
<i>Rhodotorula</i> sp.	3	5	10	16	12	19	12	15	24	31	32	53
Yeast/yeast-like	1	1	2	1	1	3	1	2	2	3	4	7
<i>Candida</i> sp.	1	0	0	3	3	4	3	1	2	7	4	6
<i>Fusarium</i> sp.	1	0	1	0	1	1	0	0	0	1	1	2
Zygomycetes	0	0	0	0	1	1	0	0	1	0	1	2
<i>Cladosporium</i> sp.	0	0	6	4	2	5	2	0	3	6	2	14
Unidentified fungus	0	0	0	2	1	3	0	1	4	2	2	7
Bacteria												
Staph/micro	1	3	5	22	14	16	9	11	12	32	28	33
Strep not D	0	0	0	0	0	0	0	0	0	0	0	0
G+ R spores (<i>Bacillus</i> sp.)	10	11	10	23	16	25	20	15	22	53	42	57
G+ R diphth/no spores	1	2	2	6	2	6	2	2	1	9	6	9
<i>E. coli</i>	0	0	0	0	1	0	0	0	0	0	1	0
<i>Serratia marcescens</i>	0	1	0	0	0	0	0	0	0	0	1	0
EGNR oxid -ve F lact +	2	2	2	2	1	4	2	0	5	6	3	11
EGNR oxid -ve F lact -ve	0	0	0	0	0	0	0	0	0	0	0	0
EGNR oxid -ve non-F	0	1	2	2	2	4	0	1	2	2	4	8
EGNR oxid +ve non-F	1	3	3	7	6	12	3	3	5	11	12	20
<i>Pseudomonas aeruginosa</i>	0	1	0	1	0	0	0	0	1	1	1	1
IW = ice bin wall; SP = ice scoop; GT = gasket.												

ing. For these samples, the swabs were rubbed over the surface in at least three directions 60 degrees from each other, with the swabs turned over at least once during the sampling to use as much of the swab surface as possible. For the ice machine gasket, swabs were rubbed along the entire length of the gasket in the groove, and especially in any areas that appeared suspicious for mold growth and/or debris buildup. During each sampling day, the

registered sanitarians prepared a field blank as a sterility check. They took the swabs out of the tube, moistened the swab with PBS, and immediately returned the swab to the tube.

Immediately after sampling, they placed the tubes in a cooler with frozen packs, and returned to the microbiology laboratory by the end of the day. Swabs were inoculated into isolation media that same day.

TABLE 4

Mean Bacteria and Fungi Relative Abundance at Each Sampling Location Within Ice Machine

Organism	Food Service Class	#	p-Value*	Gasket		Ice Bin Wall		Ice Scoop	
				Mean	SD	Mean	SD	Mean	SD
Total bacteria	All	115	.001	2.13	2.067	1.58	1.487	1.16	1.335
Total fungi	All	115	.001	3.07	3.054	1.19	1.648	0.71	0.856
Total bacteria	2	20	.122	2.55	2.585	1.30	1.455	1.55	1.791
Total fungi	2	20	.001	3.90	2.751	0.95	1.146	0.70	0.865
Total bacteria	3	53	.004	2.30	2.198	1.91	1.735	1.13	1.415
Total fungi	3	53	.001	2.72	3.301	1.11	1.565	0.75	0.83
Total bacteria	4	42	.026	1.71	1.535	1.31	1.047	1.00	0.911
Total fungi	4	42	.001	3.12	2.847	1.40	1.939	0.67	0.902

*Determined by analysis of variance (ANOVA).
SD = standard deviation.

TABLE 5

Mean Bacteria and Fungi Relative Abundance at Each Food Service Classification

Organism	Food Service Class	p-Value*	Class 2 Facilities (n = 20)		Class 3 Facilities (n = 53)		Class 4 Facilities (n = 42)	
			Mean	SD	Mean	SD	Mean	SD
Total bacteria	All	.065	1.80	2.040	1.78	1.865	1.34	1.221
Total fungi	All	.593	1.85	2.291	1.53	2.313	1.73	2.285
Total bacteria	Gasket	.237	2.55	2.585	2.30	2.198	1.71	1.535
Total fungi	Gasket	.336	3.90	2.751	2.72	3.301	3.12	2.847
Total bacteria	Ice scoop	.314	1.55	1.791	1.13	1.415	1.00	0.911
Total fungi	Ice scoop	.883	0.70	0.865	0.75	0.830	0.67	0.902
Total bacteria	Ice bin wall	.970	1.30	1.455	1.91	1.735	1.31	1.047
Total fungi	Ice bin wall	.539	0.95	1.146	1.11	1.565	1.40	1.939

*Determined by analysis of variance (ANOVA).
SD = standard deviation.

Microbiological Culturing

Plate media (tryptic soy agar [TSA], blood agar, Sabouraud agar, and MacConkey agar) were inoculated by rolling the swabs over approximately 20% of the medium surface—the “initial inoculum area.” Sterile, disposable plastic loops were used to streak in parallel lines from that initial inoculum area into three other quadrants of the medium surface. The “field blank” swabs were cultured in the same manner as the samples. As a further

sterility check of the PBS, each sampling day three or four used tubes of PBS were randomly selected and cultured.

The TSA, blood agar, and MacConkey agar plates were incubated aerobically at 35 °C, and the Sabouraud agar plates were incubated at 25 °C. After 2 and 3 days incubation, the TSA blood and MacConkey agar plates were examined for growth, and held for 5 days before reported as “no growth.” The Sabouraud agar plates were examined after

2, 3, and 5 days and held for 7 days before reporting “no growth.” For each organism isolated, a semiquantitative reporting protocol was followed (Table 1) as a measure of microorganism abundance.

The isolated fungi were identified to genus or species by standard mycological criteria based on growth rate, colony morphology, and pigmentation, plus microscopy of hyphae and sporing structures. Filamentous fungi with aseptate mycelia were identified

as “zygomycete,” with no further characterization as to genus. “Unidentified fungus” were those in which sporulation was not observed on the initial Sabouraud agar isolation medium or after subculture to potato dextrose agar. Nonpigmented yeast-like organisms were subcultured to rice extract agar with 0.1% Tween 80 and observed for pseudohyphae production at room temperature. If pseudohyphae were produced, the isolate was identified as a *Candida* species; if no pseudohyphae were seen, it was categorized as “yeast/yeast-like.”

The protocol for identifying bacteria is summarized in Table 2 (see Kassa et al., 2001, for additional detail.)

Results

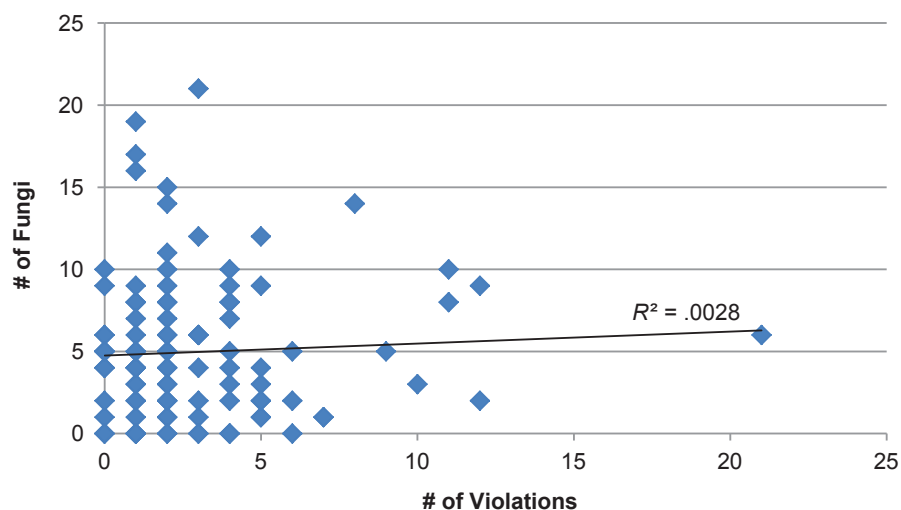
All of the food service operations studied had microbial growth on at least one of the sampling sites. In general, the microorganisms were nonpathogenic types characteristically found in fecal flora, in water, on human skin, on mucus membranes, and in environmental air and dust. A listing of the prevalence of isolated organisms is provided in Table 3.

The amount of contamination present as a function of sampling site (ice bin wall, ice scoop, and gasket) was examined as a measure of relative risk. The presence and relative abundance (determined by measuring growth on a scale of 0 to 4 as described in Table 1) of fungi and of bacteria in general varied significantly as a function of the location (ice bin wall, ice scoop, or gasket), with the largest amount of fungi and bacteria found on the gaskets (Table 4.) The only exception to this pattern was in Class 2 food service establishments, for which no significant difference was evident.

To build foundational understanding of possible differences in microbial-based risk as a function of different types of food service establishments, we examined the number and type of food service violations recorded during the previous inspection by the health department (Table 5). Analysis of variance revealed a significant difference between the facilities in the three classifications ($p < .001$). Differences between classifications 2 and 3 were least pronounced, with a significant difference between critical violations ($p = .008$), but not between noncritical violations ($p = .127$). Class 4 facilities had the greatest incidence of critical and noncritical violations.

FIGURE 1

Relative Abundance of Fungi Found at the Three Sampling Sites (Ice Bin Wall, Ice Scoop, and Gasket) and Number of Violations Cited at That Facility During Previous Inspection



Note. All replicates are included in the calculations and displayed as single points.

In contrast to the differences found between bacteria and fungi levels as a function of sampling site (ice bin wall, ice scoop, and gasket), no differences were found between relative abundance as a function of facility classification (Table 5.)

To explore possible relationships between compliance with overall food safety practices and presence of fungi and bacteria, we looked for possible relationships between citations issued at the previous inspection by the health department and the relative abundance of fungi and bacteria. The relative abundance of fungi and bacteria, respectively, found as a total from the three sampling points (ice bin wall, ice scoop, and gasket) and the total number of violations is shown in Figures 1 and 2. These figures clearly illustrate the lack of relationship between inspection results and the relative abundance of fungi or bacteria at any of the three individual sampling sites.

Discussion and Conclusions

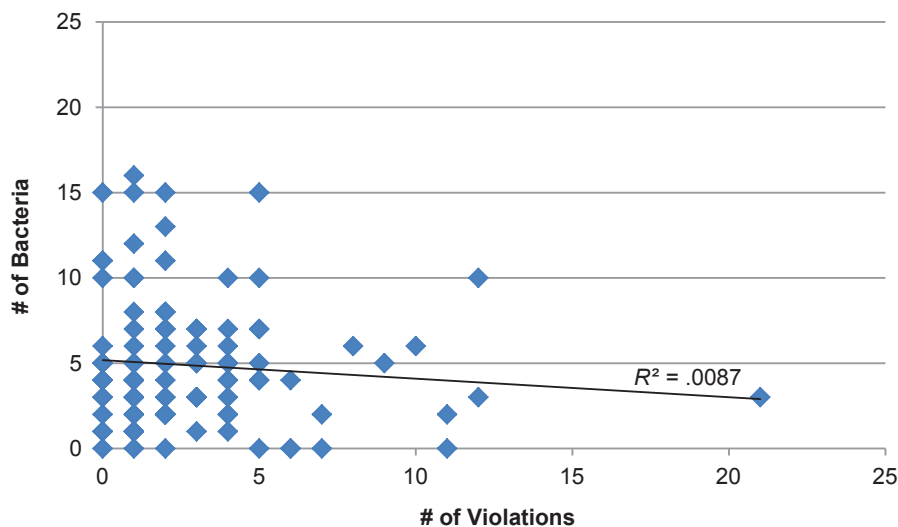
Ice machine contact surfaces typically harbored bacteria and fungi—thus providing a potential source of contamination of ice used for human consumption. Microbial

populations were not routinely of a pathogenic origin, suggesting that most ice from ice machines (assuming the origin of the water used to make the ice is from a municipal water supply) will not present a health threat. The presence of nonpathogenic organisms, however, provides evidence that the ice machine environment can support microbial pathogenic populations should they be introduced. Coupled with evidence from the literature that reports on sporadic disease outbreaks resulting from contamination of ice from ice machines, our data suggest that the health risk might not be inconsequential from ice machines associated with food service facilities.

Inspections of food service facilities typically vary as a function of associated risk. In Toledo–Lucas County, the Class 4 food service facilities averaged significantly more violations per inspection than in the other food service classes. Typically, the greater size and complexity in operations of Class 4 facilities require that inspectors spend more time there than in lower class facilities, perhaps increasing the likelihood of revealing code violations. Alternatively or additionally, a greater number

FIGURE 2

Relative Abundance of Bacteria Found at the Three Sampling Sites (Ice Bin Wall, Ice Scoop, and Gasket) and Number of Violations Cited at That Facility During Previous Inspection



Note. All replicates are included in the calculations and displayed as single points.

of violations might be found at Class 4 facilities because of inspectors' underlying awareness of a higher risk potential at these facilities, which thus increases—either intentionally or inadvertently—the intensity of their inspections. The inspection results, however, did not appear related to ice machine microbial populations. Overall, facility compliance with food safety standards does not appear to predict the level of risk from contamination of the facility's ice machines.

The evidence in the literature associating ice machines with disease outbreaks coupled with the results of this study suggest that problems from food service facilities that lead

to disease outbreaks will not be predictable (and thus not preventable) following standard inspection practices. Even though foodborne disease outbreaks are most likely to occur in food service operations with chronically high inspection violations (Kassa et al., 2001), results do not indicate this association with ice machines. Rather, no clear relationship was found between inspection results and microbial populations in ice machines.

Instead, preventing ice machines from becoming fomites might be less a matter of inspection than of maintenance and prevention. Standards for cleaning and disinfection are not part of standard food service facil-

ity operations, although the FDA *Food Code* (2013) does specify that “ice makers, and ice bins must be cleaned on a routine basis to prevent the development of slime, mold, or soil residues that may contribute to an accumulation of microorganisms.” Similarly, sanitation performance recommendations are provided in the National Sanitation Foundation [NSF] International Standards for Automatic Ice Making Equipment (NSF International, 2009). Ice machine gaskets appear to be at particular risk of contamination and therefore need special attention, perhaps reflecting their vulnerability to hand contact when ice is removed from the bin, their exposure to warmer temperatures and general air contact due to their location at the ice machine entrance, and their difficulty of cleaning compared to hard metal surfaces.

This study did not reveal a smoking gun of ice machines presenting a large threat to public health. It did, however, reveal that ice machines present some risk of foodborne outbreak, and that the risk is not being addressed by current inspection practices. Further research should be useful in determining how to better minimize microbial contamination of ice machine surfaces through practical and routine interventions. 🐞

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Corresponding Author: Gary S. Silverman, Professor, Department of Public Health Sciences, College of Health and Human Services, University of North Carolina at Charlotte, 9702 University City Boulevard, Charlotte, NC 28223. E-mail: gsilver1@uncc.edu.

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Assessing Training Needs and Competency Gaps in Food Protection Staff

William A. Mase, MA, MPH, DrPH
 Bobbie Jo Newell, MEd
 H. Pamela Pagano, MPH, DrPH, CPH
 Jessica Arrazola, MPH, DrPH, CHES
*Department of Health Policy
 and Management
 Jiann-Ping Hsu College of Public Health
 Georgia Southern University*

Abstract This study assessed the training needs and knowledge gaps across five competency domains among the food protection staff of the Cincinnati Health Department. The five overarching competency domains assessed included 1) scientific knowledge; 2) foodborne illness knowledge, rules, and regulations; 3) temperature and storage; 4) inspection equipment; and 5) communication. A full network workforce assessment was conducted in a 3-year prospective longitudinal study design. Key findings show that competency areas identified as needing attention improved over time. The domain that consistently showed the highest percentage of workforce needing improvement was foodborne illness knowledge, rules, and regulations.

Introduction

Approximately 48 million people in the U.S. become sick with foodborne illness every year (Scallan et al., 2011). While 1 in 6 become ill, 128,000 are hospitalized and an estimated 3,000 die of foodborne illness (Scallan et al., 2011). Food safety and foodborne illness prevention is a primary responsibility of local public health departments. At the local level, environmental health practitioners work with food service outlets and food distribution centers to enforce food safety regulations. According to the Centers for Disease Control and Prevention (CDC), the food safety workforce addresses 4 of the 10 Essential Public Health Services, including: diagnosing and investigating health problems and health hazards in the community; informing, educating, and empowering people about health issues; enforcing laws and regulations that protect health and ensure safety; and assuring competent public and personal healthcare. The ability of the nation's local public health workforce to effectively fulfill their responsibilities is limited by competence, consistency, and the capacity of the workforce (Centers for Disease Control and Prevention, 2014).

In 2013, 13,300 local public health agency employees were identified as environmental health workers, a decrease of 13% of the workforce from the 2008 estimates of 15,300 (National Association of County and City Health Officials, 2014). The decline of environmental health workers affects the health department's ability to ensure an adequate food safety workforce. This decline in staffing capacity of the food safety workforce within local health departments is expected to continue, with contributing factors such as the anticipated retirement of employees within the workforce, salary stagnation, and lack of opportunity to attract new hires (National Environmental Health Association [NEHA], 2013). With more environmental health workers leaving the workforce and fewer joining, the nation's food safety and security capacity is vulnerable.

Standardization of knowledge and behavior of the food safety workforce is a strategy to reduce the potential for incidences of foodborne illness, even given the limited capacity of the workforce. Standardization of knowledge and behavior results from training the current workforce based on national

evidence-based standards addressing outbreak detection, response capacity, capacity to implement control measures, and capacity to implement prevention activities (NEHA, 2013). Adoption of national guidance and participation in continuing education opportunities varies among health departments, despite available resources (NEHA, 2013).

Few national resources exist to guide the development and implementation of food safety training for environmental health workers. The Council to Inform Foodborne Outbreak and Response (CIFOR) has developed standardized guidance for outbreak detection and response, but an estimated 30% of environmental health regulatory programs have not adopted these guidelines (CIFOR, 2014). The International Food Protection Training Institute has designed a competency-based career-spanning curriculum framework to provide continuing education opportunities and to establish a career path for the food safety workforce (Kaml et al., 2013). The Environmental Public Health Online Courses is an online training series preparing practitioners to take credentialing exams for national environmental health certifications (McCormick & Pevear, 2013). Despite available training resources, local health departments continue to report a greater need for training compared with state health departments (NEHA, 2013).

Foodborne illness outbreak response efforts are complex and frequently require collaboration among local, state, and national agencies. An inadequately trained workforce can lead to the omission of investigative actions, duplication of efforts, and delays in source identification—leading to wasted resources and excess risk to the public (NEHA, 2013). In contrast, a highly trained and skilled workforce can result in significantly reduced healthcare costs due to lower rates of death and disease (Neis-

TABLE 1

Demographics of Study Participants

Demographics	2013–2014 # (%)	2014–2015 # (%)	2015–2016 # (%)
Gender			
Female	8 (47.1)	8 (72.7)	9 (69.2)
Male	7 (41.2)	3 (27.3)	3 (23.1)
Missing	2 (11.7)	0 (0)	1 (7.7)
Race/ethnicity			
White	11 (64.7)	7 (63.6)	8 (61.5)
Asian	2 (11.8)	2 (18.2)	1 (7.7)
Black or African American	1 (5.9)	2 (18.2)	2 (15.4)
Spanish, Hispanic, or Latino	0 (0)	0 (0)	1 (7.7)
Missing	2 (11.8)	0 (0)	0 (0)
Other	1 (5.8)	0 (0)	1 (7.7)
Age			
18–24	0 (0)	0 (0)	0 (0)
25–34	1 (5.9)	0 (0)	1 (7.7)
35–44	5 (29.4)	2 (18.2)	4 (30.8)
45–54	4 (23.5)	6 (54.5)	5 (38.5)
55–64	4 (23.5)	3 (27.3)	3 (23.1)
65–74	0 (0)	0 (0)	0 (0)
≥75	0 (0)	0 (0)	0 (0)
Missing	3 (17.6)	0 (0)	0 (0)
Education			
High school	0 (0)	0 (0)	0 (0)
Associate's degree	0 (0)	0 (0)	0 (0)
Bachelor's degree	13 (76.5)	9 (81.8)	11 (84.6)
Graduate degree (MS, MPH, PhD, MD)	4 (23.5)	2 (18.2)	2 (15.4)

Demographics	2013–2014 # (%)	2014–2015 # (%)	2015–2016 # (%)
Job classification			
Senior sanitarian	2 (11.8)	0 (0)	2 (16.7)
Registered sanitarian	11 (64.7)	11 (100)	10 (83.3)
Sanitarian in training	2 (11.8)	0 (0)	0 (0)
Missing	1 (5.9)	0 (0)	0 (0)
Other	1 (5.9)	0 (0)	1 (0)
Percent of time per week working on food safety-related work			
<10%	3 (17.6)	0 (0)	1 (7.7)
10%	0 (0)	1 (9.1)	1 (7.7)
20%	2 (11.8)	0 (0)	2 (15.4)
30%	1 (5.9)	1 (9.1)	0 (0)
>30%	9 (52.9)	9 (81.8)	8 (61.5)
N/A	2 (11.8)	0 (0)	1 (7.7)
Currently licensed as a registered environmental health specialist/registered sanitarian (REHS/RS) in Ohio			
Licensed	15 (88.2)	11 (100)	13 (100)
Not licensed	2 (11.8)	0 (0)	0 (0)
Years since completing the REHS/RS exam			
<5 years	1 (5.9)	4 (36.4)	3 (23.1)
5–10 years	5 (29.4)	1 (9.1)	3 (23.1)
11–15 years	2 (11.8)	3 (27.3)	2 (15.4)
16–20 years	1 (5.9)	1 (9.1)	3 (23.1)
>20 years	5 (29.4)	1 (9.1)	2 (15.4)
N/A	3 (17.6)	1 (9.1)	0 (0)

tadt & Murphy, 2009). A trained and prepared environmental health workforce is essential to ensuring food safety, and ultimately the safety of the public's health.

Methods

Participant Recruitment

The inclusion criteria to participate in the study required current employment as a food protection staff member with the Division of Environmental Health at the Cincinnati Health Department during fiscal years 2013, 2014, and/or 2015. All members of the food protection staff

were invited to voluntarily complete the survey each of the 3 years. The food safety staff received an e-mail from the principal investigator requesting anonymous participation. All staff were granted permission from their supervisor to complete the survey during paid work time on health department computers. The survey was distributed as a SurveyMonkey link.

Survey Development and Administration

The survey questionnaire consisted of 57 questions. Both quantitative and qualitative questions were included in the workforce sur-

vey. The survey was divided into three major categories: job-related questions, workforce competencies, and demographic data.

Participants were asked to report job classification, percent of time per week spent on food safety-related work, and if they held a current registered environmental health specialist/registered sanitarian (REHS/RS) license in Ohio. If they held a current license, they were asked what year they had completed the exam. The survey captured years of experience in public health, years at the Cincinnati Health Department, as well as total years across all professional positions held in food safety.

The workforce competencies section asked participants to score each of the five competencies: science knowledge; foodborne illness knowledge, rules, and regulations; temperatures and storage; inspection equipment; and communication. Respondents self-assessed their perceived importance of each on a 4-point Likert scale of not at all important, low importance, moderately important, or very important. The survey also assessed workforce interest in additional training, ability to perform job, and self-reported importance to job for each competency.

Lastly, participants were asked to report personal demographic data. Participants were given the opportunity to provide additional comments regarding each competency, as well as the FDA Food Protection Staff Needs Assessment Survey. Data collection was open for a minimum of 10 days during each year of data collection.

Data Analysis

Personal identifiers were not collected. Summaries of demographic variables such as gender, race/ethnicity, age, education, and job classification were calculated to show the differences across the 3 years of data collection. The data were also analyzed to show the average number of years worked in public health, years at the Cincinnati Health Department, and years in food safety at any location. We analyzed the data and generated descriptive data tables using Microsoft Excel.

Mean averages of the workforce interest in additional training, ability to perform job, and self-reported importance to job were calculated across each of the five overarching competency domains. We analyzed data trends across all 3 years. We calculated need-for-training scores for each of the five areas. Of specific interest were scores that demonstrated a negative score as a product of the difference between an individual's self-reported importance-to-job score and the corresponding ability-to-perform score. When the resulting score was negative, that competency or skill was considered to have a negative need score (NNS). The specific competencies or skills with a greater proportion of the workforce demonstrating a NNS were targeted to be addressed in the following year. We then compared data trends across 2013–2014, 2014–2015, and 2015–2016.

TABLE 2

Relevant Work History in Average Number of Years

Field of Work	2013–2014 (Years)	2014–2015 (Years)	2015–2016 (Years)
Worked in public health	15.8	19.7	18.5
Worked in food safety	6.9	8.0	10.6
Worked in the Cincinnati Health Department	12.8	14.4	16.7

Results

There were a total of 41 non-mutually exclusive food protection staff within the Division of Environmental Health at the Cincinnati Health Department who participated in the study (17 in 2013–2014, 11 in 2014–2015, and 13 in 2015–2016). As a workforce quality improvement (QI) initiative, it is important to note that the majority of the workers completing the survey were employed across all 3 years and are represented in each of the years for which data are presented. We collected demographic information of the study participants (Table 1) and relevant work history (Table 2).

Scores were calculated for each question on the assessment using a 4-point Likert scale, where higher scores indicated higher importance. We used averages to summarize the assessment category. Scores from each of the five competency areas were similar across all 3 years of the study; only small incremental changes were observed. We provide a comparison of the five areas assessed by the competency assessment instrument (Figure 1).

NNSs were calculated for each of the five competency areas as the ability-to-perform score minus the importance-to-job score. We provide a comparison of the percent of respondents' NNSs across the five competencies in all 3 years that the survey was conducted (Figure 2).

In years 2014–2015 and 2015–2016, under the scientific knowledge competency, the question related to understanding the epidemiological process of a foodborne illness outbreak has continued to have numerous NNS responses. Under the foodborne illness knowledge, rules, and regulations competency, several questions have continued to have NNSs and remain areas in which additional attention is recommended, while others improved through the years, indicat-

ing attainment of competencies. Knowledge of control measures for the risk factors known to contribute to foodborne illness remained consistent, with the same number of NNS respondents from 2014–2015 and 2015–2016. Encouragingly, the NNS for responding to a foodborne illness outbreak improved in 2015–2016 from the previous 2 years. Understanding the good retail practices improved greatly from 2014–2015 to 2015–2016. The temperature and storage competency also had one question, about the knowledge of adulterated foods, that increased in NNS every year. In addition, under the inspection equipment competency, identifying restaurant food equipment and its use had the highest NNS, increasing by one every year since 2013–2014. The communication competency had one question, applying conflict resolution skills when necessary, that has consistently had NNS responses in 2013–2014, then decreased in 2014–2015, and increased again in 2015–2016.

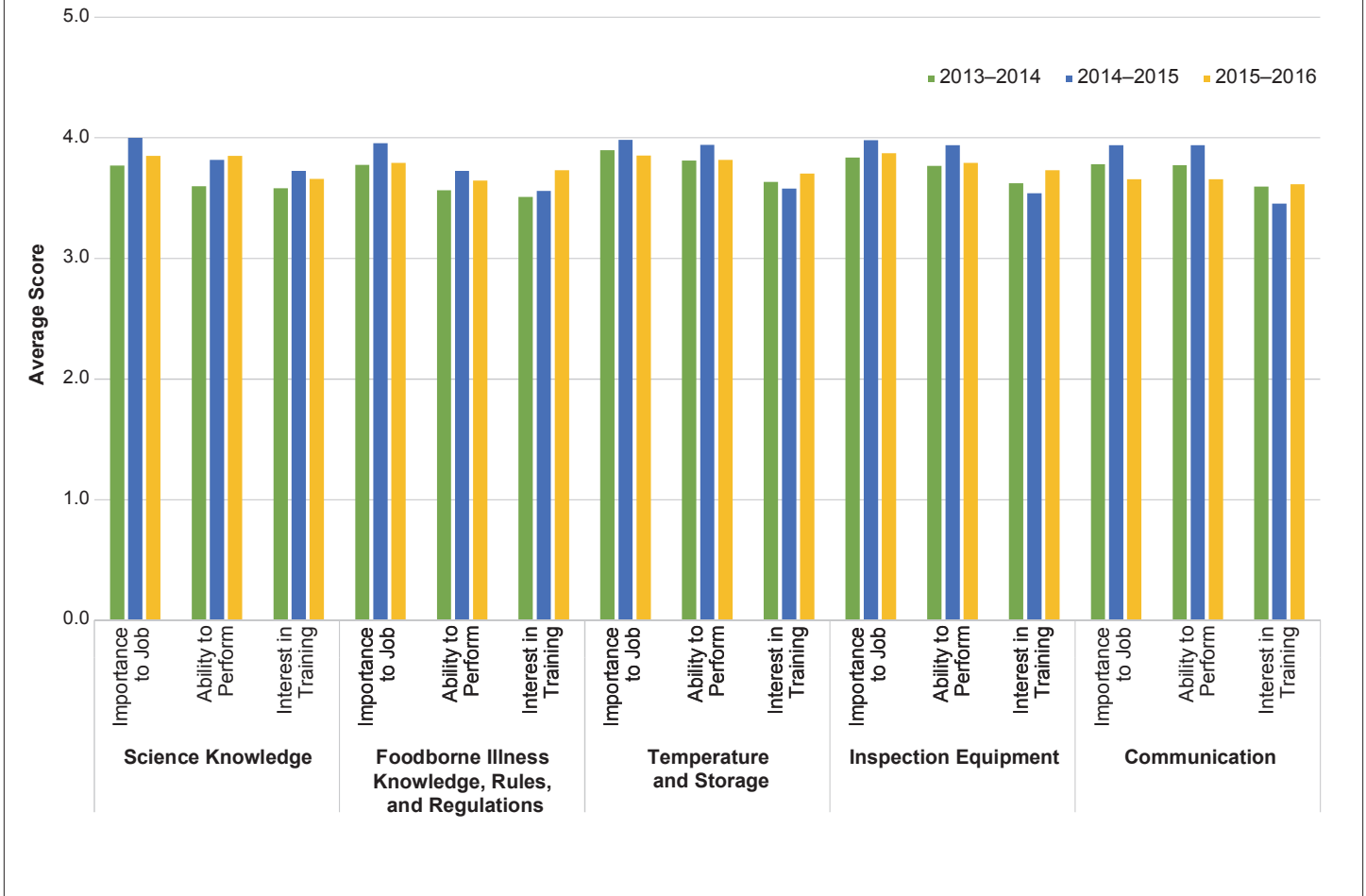
Discussion

An assessment of foodborne illness risk factors by the Cincinnati Health Department identified a positive association between the risk class of the food establishment and the risk of foodborne illness (Sharkey, Alam, Mase, & Ying, 2012). In response, the Cincinnati Health Department has attempted to reduce the number of risk factors at food establishments by providing standardized training to their food safety workforce. The existing published literature on the training and capacity experience of the food safety workforce is limited and warrants further analysis of standardized knowledge and behavior in this workforce.

The Cincinnati Health Department has revised the standard operating procedures (SOPs) for the food safety workforce as part

FIGURE 1

Competency Summary Averages Across 2013–2014, 2014–2015, and 2015–2016



of an ongoing QI process to standardize the knowledge and behavior of food safety staff. First, as part of a 2013 Food and Drug Administration (FDA) grant, the food safety staff worked as a team to develop an SOP manual and food safety workforce handbook; both documents are reviewed and updated annually. The objective to train the staff working in the field is to ensure that all workers look for any issues and risks as potential causes of foodborne illness in the community. Second, the health department developed and implemented a food safety staff train-the-trainer model based on FDA recommendations. All staff members participate in the standardized training and complete 40 hr of online coursework, conduct eight joint community food establishment inspections with a trainer,

and complete the hazard analysis and critical control point (HACCP) training for retail and food service establishments (FDA, 2017). In addition, all staff are required to shadow inspections with a certified trainer and to successfully complete the ServSafe training program. Lastly, based on the training and SOPs, a manual of internal staff policies and procedures was created that governs staff training and operations.

Food protection staff should maintain professional levels of knowledge through competency-based, career-spanning curriculum and continuing education opportunities (Kaml et al., 2013). The economic costs for foodborne illness in Ohio is estimated to be \$1–\$7.1 billion per year or approximately \$91–\$624 per Ohio resident (Scharff, McDowell, &

Medeiros, 2009); yet budget constraints continue to affect local health departments, making it increasingly important to standardize knowledge and trainings for staff. Continuing education and practical training experiences standardize competencies among the food safety staff to effectively fulfill their obligations as delineated by the 10 Essential Public Health Services (CDC, 2017).

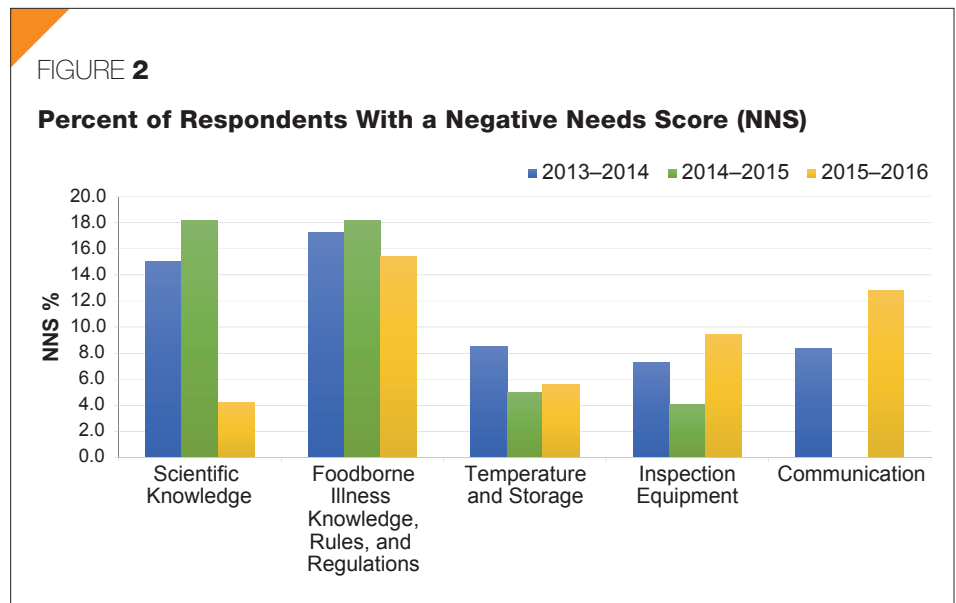
One limitation of this study is the small number of participants, especially after considering the loss of staff during the study period, despite the 100% response rate across all 3 years of data collection. Furthermore, maintaining anonymity of the participants prevented identification of individual staff members who need training. While the study was limited to current food protection staff at

the Division of Environmental Health at the Cincinnati Health Department, the results may inform workforce QI among food safety workers at other local health departments.

The utility of this type of workforce needs assessment is its ability to serve as a tool for local public health departments to generate workforce-level measures across the five assessment domains. The assessment can provide workforce-level feedback as to task-specific importance to job, ability to perform tasks, and interest in additional training. Ultimately, these three assessment benchmarks and continued measurements can be used as key workforce QI measures, and should be used to inform workforce planning efforts.

Conclusion

Providing standardized knowledge and behavior training for food safety workers is critical for local health departments with increasingly limited staffing resources. The study results yield moderate evidence of food protection staff needing additional training to perform their job; the moderate evidence is possibly the result of the division having a standardized training mechanism already in place, whereas many local health departments do not. Communication needs of the communities served are constantly changing, reinforcing the dramatic shift in the perceived attainment of communication competencies from year to year. Food regulations can vary slightly from one area to another; however, conclusions from this study show the benefits of food protection workers establishing standardized skills and knowledge to enhance performance and food safety. Future studies could include focus



groups or one-on-one interviews to gain an understanding of specific training needs and to inform revisions to training and SOP manuals. Results from this study can inform policies, standard training curriculum, and operating procedures for improving foodborne disease knowledge, surveillance, and control to lighten the heavy burden caused by foodborne illness. 🐷

Acknowledgements: The authors would like to thank the Cincinnati Health Department in Ohio for participating in this study. The authors extend their heartfelt gratitude and appreciation to Dr. Mohammad Alam, Gail Long-Cook, Dale Grigsby, Dr. Camille Jones, Ken Sharkey, and all members of the Cincinnati

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Corresponding Author: William A. Mase, Assistant Professor, Department of Health Policy and Management, Jiann-Ping Hsu College of Public Health, Georgia Southern University, 501 Forest Drive, Statesboro, GA 30458-8015. E-mail: wmase@georgiasouthern.edu.

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► BUILDING CAPACITY



Darryl Booth, MBA

Fort Worth Builds Capacity Through a Customer Focused and Consolidated Delivery of Municipal Services

Editor's Note: A need exists within environmental health agencies to increase their capacity to perform in an environment of diminishing resources. With limited resources and increasing demands, we need to seek new approaches to the business of environmental health.

Acutely aware of these challenges, NEHA has initiated a partnership with Accela called *Building Capacity*. *Building Capacity* is a joint effort to educate, reinforce, and build upon successes within the profession, using technology to improve efficiency and extend the impact of environmental health agencies.

The *Journal* is pleased to publish this bimonthly column from Accela that will provide readers with insight into the *Building Capacity* initiative, as well as be a conduit for fostering the capacity building of environmental health agencies across the country.

The conclusions of this column are those of the author(s) and do not necessarily represent the views of NEHA.

Darryl Booth is senior vice president and general manager of environmental health at Accela and has been monitoring regulatory and data tracking needs of agencies across the U.S. for almost 20 years. He serves as technical advisor to NEHA's informatics and technology section.

Innovation is as much an element of internal culture (read, leadership) as it is of bright and forward-thinking individuals, and this culture often runs deep and is lasting. The Samuel J. Crumline Consumer Protection Award (www.crumlineaward.com) is presented annually to local health jurisdictions that show this kind of leadership. We've kept in touch with several past awardees.

2004 Crumline Award Winner: Fort Worth Consumer Health Division (CHD), Texas

At the time of CHD's 2004 Crumline application, 24 full-time employees were responsible for protecting the safety of nearly 600,000 residents. Despite a constricted economic and hiring environment, Fort Worth was dedicated to becoming "the safest city in America" and maintaining an exemplary level of programming, performance, and protection.

CHD put forth a long-term plan to implement 10 strategic initiatives that included such goals as innovation in technology, community partnerships, personnel training, and a staff committed to "prevent, rather than respond to, undesirable consumer health issues." To optimize its efforts, the division embraced training across traditionally siloed responsibilities. Of the 24 full-time employees, 15 were elevated to a consumer health specialist title, an enhanced version of the traditional sanitarian title.

CHD found that this integrated team approach maximized its effectiveness and gave staff the opportunity to develop and embrace ownership of larger public health challenges. The division was careful to foster this professional development through ongoing continuing education in food, pool, environmental, and child care safety areas. Beyond building up its staff, CHD also focused on building relationships within the local professional, regulatory, and education communities.

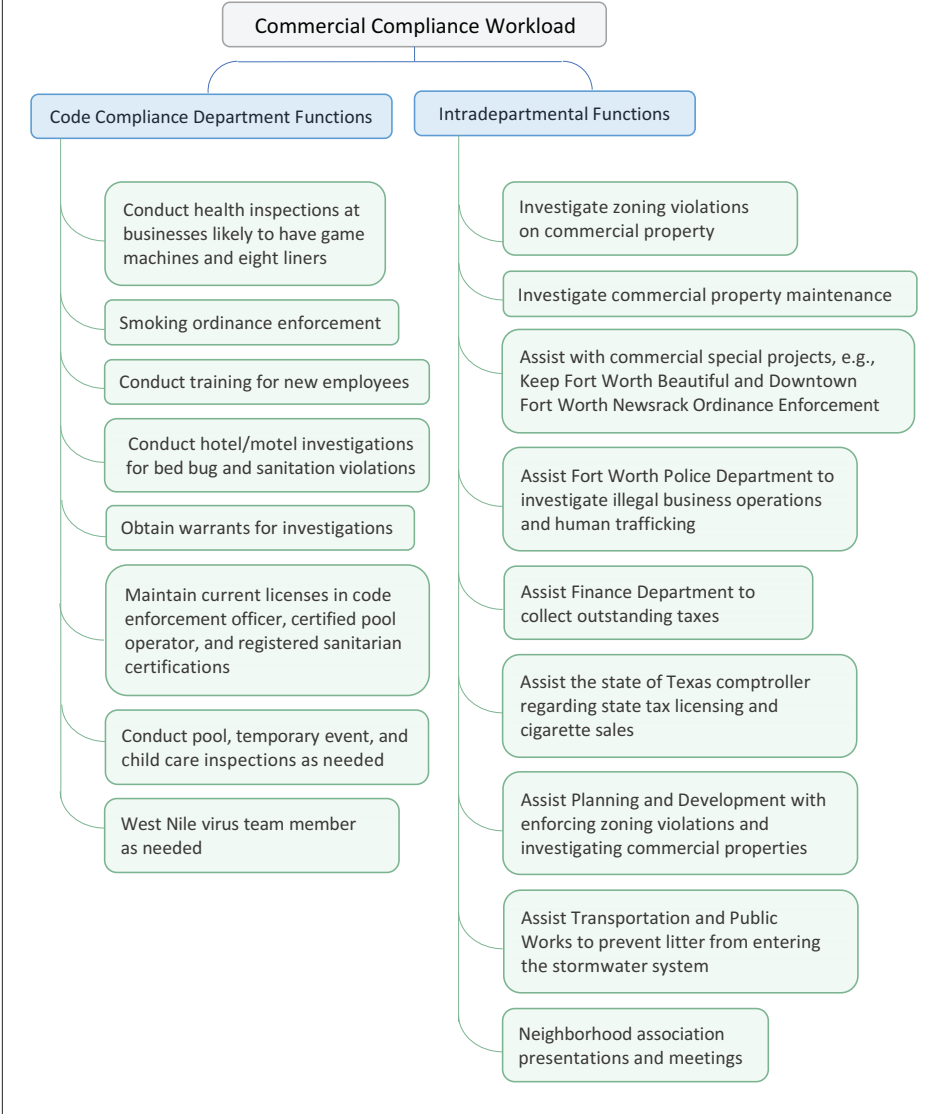
By the time CHD received its well-deserved 2004 Crumline Award, the division clearly had prioritized leveraging relationships and the sharing of the knowledge and expertise that came from those investments as key components of its success. Thirteen years later, CHD continues to innovate on this foundation.

Fast Forward to 2017

Like many local government entities, the 2008 recession impacted CHD's resources and capacity. At the same time, the population of Tarrant County, the county in which Fort Worth is located, was growing exponentially and had doubled in just one decade. All these factors put a further strain on CHD's already restricted funding and services.

FIGURE 1

Itemization of the Commercial Compliance Team's Traditional Environmental Health and Intradepartmental Responsibilities



CHD's mandate, however, to be customer-focused and efficiency-driven continued. The division delivered on this promise by leveraging and expanding on the success it had with its cross-trained consumer health specialists. Recently, CHD added a new team to its division, the commercial compliance specialists team.

The commercial compliance team originated almost by accident. In 2014, Fort Worth's Planning and Development Department passed an ordinance about gaming

rooms to crack down on illegal gambling. The program was assigned to the Code Enforcement Department, but lack of additional funding meant that the department had to get creative (Note, in 2008, several of the Fort Worth Public Health Department's functions were outsourced and the rest of consumer health was moved to the Code Enforcement Department. Consumer health still manages many of the standard environmental health programs such as food safety, hotel and pool/spa inspections, and vector control).

"Regardless of funding, somebody had to own it," explains Gwynne Turpen, CHD consumer health superintendent. "We were already visiting many of these businesses as a part of our consumer health activities, so it naturally fell to us because it was the most cost-effective way to handle it. We certainly didn't want to be sending three different city employees to visit the same establishment."

CHD realized that to effectively meet this mandate and ensure its personnel's success, it had to create a much more complex consumer health specialist. So, a set of Fort Worth senior-ranking consumer health specialists were selected to be cross-trained in code enforcement. Today, they are registered as both sanitarians and code enforcement officers, and they work closely with the Planning Department (Figure 1).

For the commercial compliance team, it's all about closing the loop. Though they are consumer health employees, they are able to deliver a more unified and consistent customer experience because they have expertise that spans multiple city departments. They can handle extremely complex properties and issues, considering both the public health laws and the zoning laws. They are even trained to recognize the signs of human trafficking and illegal gambling. As senior members of the CHD team, they are held to a higher standard and are required to maintain more education and knowledge. For example, when they visit a property, they have an answer for almost any issue or question that might arise and if they don't, they know who does.

"This team invests time in facilitating communications between businesses and city department employees, from the Water Department, the police, the Planning Department, and even the Forestry Department," says Turpen. "Instead of saying, 'Oh, you need to go talk to Planning' and then leaving the customer to it, our teams will facilitate the introduction to the right individual in the Planning Department and monitor the case to resolution. We'll work through any issue—even if it's not our issue! Our goal is to resolve it, get the customer in compliance, and move on."

In the beginning, the program was a bit ad hoc. Besides training, CHD staff had to locate the right resources in its partner departments, engaging in a bit of political niceties.

“It was just a matter of finding out who to call, which can be hard at first. But you just call and call, and when someone answers the phone, you start building the relationship. You’re polite and grateful. You send follow-up e-mails thanking them and letting them know how they helped the customer. I remind my team to ‘cc’ these people’s bosses so that they feel recognized when they put in the extra effort.”

Fort Worth currently has a team of six, one-stop shop commercial compliance specialists. They handle the more complex establishments in the city. The consumer health specialist role still exists and if they see something while out on an inspection that might warrant the expertise of a commercial compliance specialist, they can call their counterpart, explain the situation, and ask for next steps.

The efficiencies gained by removing the silos between multiple municipal organizations and going the extra mile to resolve uncertainties for customers not only provides

better public service but also makes the entire local government more efficient. It was, says Turpen, time for environmental health and the city to become more visible and relevant. “Environmental health and many municipal services generally like to stay off the radar. So, we started to focus on what else can we do to demonstrate everything that we do for the public.”

Elmer DePaula, assistant director for Fort Worth’s Code Compliance, Consumer Health, and Environmental Management Department, agrees and cites the changing economy as driving this innovative interpretation of city and public health service delivery. As staff budgets contracted after the recession, the city found that it had to double down, be more efficient, and prove its necessity. “We realized we could not function in a siloed mode; we had to work horizontally. We needed to adapt to the new economy. Our commercial compliance team helps us be more responsive and efficient, and deliver a better customer experience,” states DePaula.

Besides the efficiency that this team delivers for city services, Turpen emphasizes that they measure the value of this team by their reputation and perception. “We’re trusted. We end up owning a lot of stuff that’s not ours, but that’s good customer service. All our city council members know us, which is wonderful. It’s fantastic that our leaders can say, ‘I’m going to send you to Jim to take care of you,’ and know that Jim will take care of it.” She laughs and remarks, “Sometimes it’s a struggle being this popular, but my staff are trained to own it until it’s not theirs.” 🐶

Acknowledgement: Kelly Delaney, product marketing associate for Accela, contributed research for this column.

Corresponding Author: Darryl Booth, Senior Vice President and General Manager of Environmental Health, Accela, 2633 Camino Ramon #500, San Ramon, CA 94583. E-mail: dbooth@accela.com.

Did You Know?

The Samuel J. Crumbine Consumer Protection Award was established in 1954 and was first awarded in 1955. The award is named in honor of Dr. Samuel J. Crumbine, a sanitarian-physician and public health pioneer who was renowned for his innovative methods of improving public health protection. You can view recent Crumbine winner entries at www.crumbineaward.com/Crumbine-Award-Winning-Entries.



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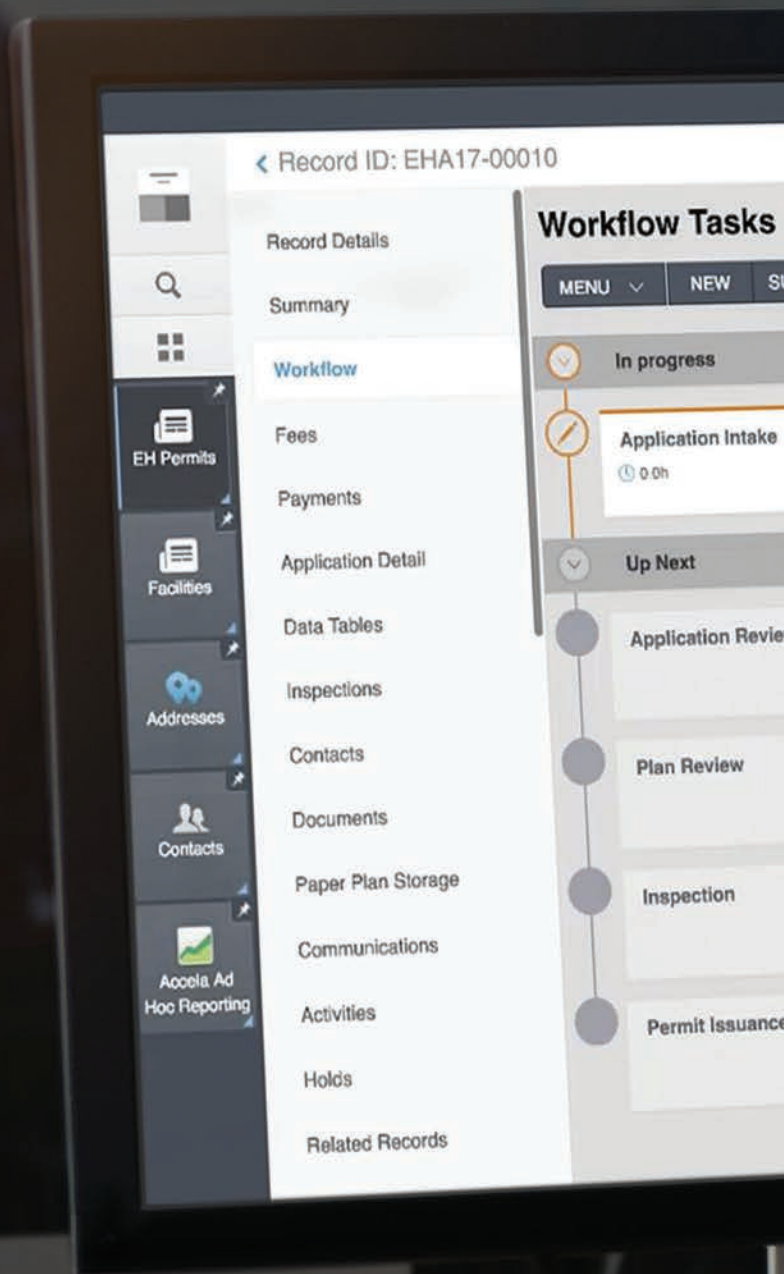
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▶ DIRECT FROM ATSDR



Stephen Richardson

Evaluating Potential Health Effects of Secondary Drinking Water Contaminants

Editor's Note: As part of our continuing effort to highlight innovative approaches to improving the health and environment of communities, the *Journal* is pleased to publish a bimonthly column from the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is a federal public health agency of the U.S. Department of Health and Human Services (HHS) and shares a common office of the Director with the National Center for Environmental Health (NCEH) at the Centers for Disease Control and Prevention (CDC). ATSDR serves the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances.

The purpose of this column is to inform readers of ATSDR's activities and initiatives to better understand the relationship between exposure to hazardous substances in the environment and their impact on human health and how to protect public health. We believe that the column will provide a valuable resource to our readership by helping to make known the considerable resources and expertise that ATSDR has available to assist communities, states, and others to assure good environmental health practice for all is served.

The conclusions of this column are those of the author(s) and do not necessarily represent the official position of ATSDR, CDC, or HHS.

Stephen Richardson is an environmental health scientist with ATSDR's Division of Community Health Investigations. He has more than 25 years of experience assessing potential health risks from human exposure to environmental contaminants.

Introduction

The Agency for Toxic Substances and Disease Registry (ATSDR) evaluates the individual and combined health effects of exposure to contaminants found in private drinking water. ATSDR initially screens the environmental contaminant data with existing health comparison guidelines and water quality standards. Many contaminants found in

private well water can be considered more of a nuisance for the consumer than a health issue.

The U.S. Environmental Protection Agency (U.S. EPA) has established nonmandatory, secondary drinking water standards for 15 of these contaminants known as Secondary Maximum Contaminant Levels (SMCLs). The main concern for these contaminants is that they might cause aesthetic effects (unde-

sirable taste, odor, or color); cosmetic effects (such as skin or tooth discoloration); or technical effects (such as corrosion or staining of household plumbing or fixtures).

By law, U.S. EPA drinking water standards (both primary and secondary) are only applicable to public drinking water; however, they are often used as screening values to determine potential problems in private drinking water supplies. ATSDR's experience in addressing private well contamination indicates that while several metals with an SMCL might only appear as an aesthetic issue for the consumer, they can potentially be harmful at levels above the SMCL. Moreover, exposure to several of these secondary contaminants, when combined with other contaminants in the water, might have an enhanced adverse health effect. The case study that follows is an example of this water quality issue, along with ways to ensure safe drinking water.

Case Study: Pearce Creek Dredged Material Containment Area

Site Background

The Pearce Creek Dredged Material Containment Area (DMCA) is located in Cecil County, Maryland. Several small communities border the DMCA (Figure 1) and residents rely on private wells to meet their household water needs.

The U.S. Army Corps of Engineers (USACE) disposed of dredged material (sediments) from the Chesapeake Bay and Delaware Canal into the Pearce Creek DMCA from 1937 to 1938 and then again from the 1960s to 1993. In response to concerns that contaminants from the DMCA were affecting nearby residential well water, USACE

FIGURE 1

Map of Pearce Creek Dredged Material Containment Area (DMCA) and Surrounding Areas



Source: www.pearcecreekoutreach.com/Images/DMCF/PearceCreekDMCA_AreaMap_wLake_11x17.png.

discontinued disposal of dredge material into Pearce Creek.

In 2012, the U.S. Geological Survey reported that contaminants from dredged material in the Pearce Creek DMCA had degraded local groundwater quality. Several metals detected in groundwater samples exceeded U.S. EPA primary or secondary drinking water standards. In 2013, follow-up sampling by the Cecil County Health Department confirmed that the concentrations of metals in many residential wells near the DMCA exceeded U.S. EPA drinking water standards.

In July 2014, the Cecil County Health Department requested ATSDR to address two specific health concerns regarding elevated levels of metals found in residential drinking water wells near the Pearce Creek DMCA:

1. Can exposure to individual contaminants (such as aluminum, manganese, and iron) at concentrations exceeding U.S. EPA SMCLs pose a public health hazard?
2. Are synergistic effects possible from exposure to multiple contaminants at concentrations exceeding SMCLs? That is, can the combined effect from exposure to a mixture of such contaminants be greater than

the sum of the effects from exposure to the contaminants individually?

ATSDR's Site Evaluation

ATSDR evaluated water sampling data, collected between 1987 and 2013, from approximately 187 residential wells near the Pearce Creek DMCA. ATSDR assessed the exposures using ATSDR's public health assessment evaluation process and reviewed available scientific literature regarding the effect of chemical interactions on the overall potential adverse health effects of contaminant mixtures.

Health Effects of Secondary Contaminants

Health guideline values, such as ATSDR minimum risk levels (MRLs) and U.S. EPA reference doses (RfDs) were used to evaluate potential health effects from exposure to hazardous substances in the drinking water. A health guideline value is an estimate of daily human exposure to a substance that is unlikely to cause harmful, noncarcinogenic health effects. For some secondary contaminants, MRLs and RfDs have not been established. We reviewed ATSDR's Toxicological Profiles and other toxicological infor-

mation sources to estimate contaminant levels (or doses) that might cause adverse health effects. Contaminant-specific drinking water exposure doses for residential well users were estimated and compared to available health effect levels.

Some secondary contaminants, such as chloride, iron, and sodium, are also essential nutrients. For these contaminants, we compared drinking water exposure doses to the National Institute of Medicine's established tolerable upper intake levels, where available. These upper intake levels represent the highest level of daily nutrient intake from all dietary sources that is likely to pose no risk of adverse health effects to almost all individuals in the general population.

Mixture Effects (From Coexposure to Multiple Contaminants)

For possible synergistic effects from exposure to multiple synergistic contaminants at concentrations exceeding SMCLs and other ATSDR health comparison values, we first evaluated possible harmful health effects from exposures to individual contaminants. ATSDR determined that individual exposures to several contaminants found in drinking water might cause harmful, noncancer health effects, including

- gastrointestinal problems in children and adults (copper, iron, and sulfate);
- neurological, behavioral, or neurodevelopmental effects in children (aluminum, lead, and manganese); and
- neurological effects in adults (aluminum and manganese).

Scientific literature on nervous system effects from coexposure to aluminum, lead, and manganese, and gastrointestinal effects from coexposure to copper, iron, and sulfate were inadequate to assess possible joint toxic interactions for these two contaminant mixtures. ATSDR conservatively assumed that the adverse effects were additive so that the potential hazard of each mixture can be estimated by summing the health hazard of the individual chemicals. Therefore, for individuals drinking water from residential wells near the Pearce Creek DMCA, the potential risk of neurological effects from exposure to mixtures of manganese, lead, and aluminum, or gastrointestinal effects from exposure to mixtures of copper, sulfate, and iron is likely greater than the risks that would be expected from exposure to any of these contaminants individually.

More detailed information on ATSDR's toxicological evaluation of contaminant mixtures for this site can be found in the documents referenced below (U.S. Department of Health and Human Services, 2016, 2017).

Impact of ATSDR's Public Health Conclusions and Recommendations

ATSDR concluded that drinking well water from some residential wells near the Pearce Creek DMCA could harm people's health, and individuals exposed to contaminant mixtures might have a greater risk of harmful effects than the risk that would be expected from exposure to any of these contaminants individually. ATSDR recommended that until homes are connected to the municipal water system, residents with private wells use bottled water for drinking and cooking.

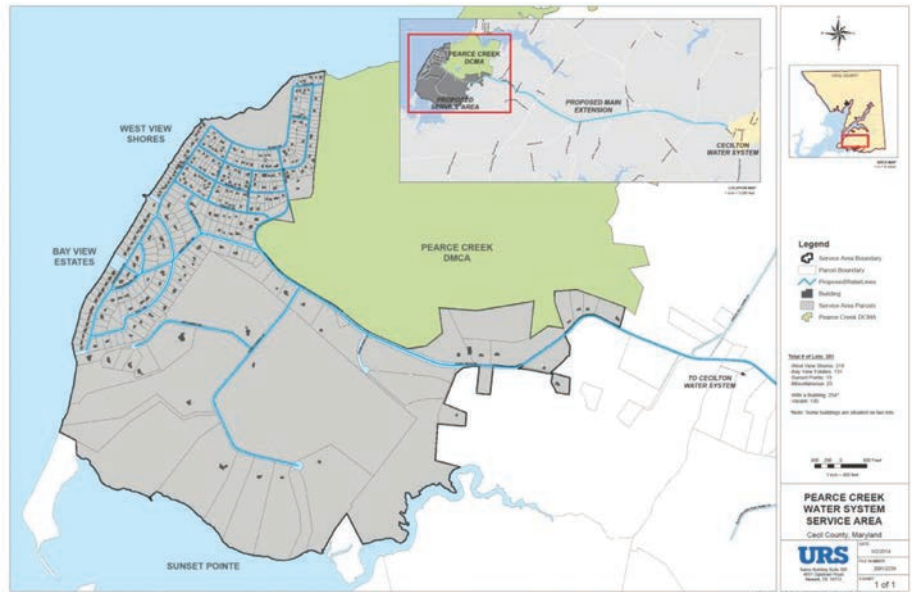
In response to ATSDR's findings that private drinking water could harm people's health, the Maryland Department of the Environment announced that USACE and the Maryland Port Authority were providing bottled water free of charge to area residents until their homes are connected to the Town of Cecilton municipal water system (Figure 2.) These actions helped reduce potential harmful exposures to contaminated drinking water for more than 600 people living near the Pearce Creek DMCA.

Public health officials faced with a similar exposure scenario should be aware that harmful effects from water contaminants that are considered an essential metal or only a concern for aesthetic or other reasons, could be harmful if the levels are high enough and when the health effects of exposure to all contaminants in the water mixture are considered. 🦋

Corresponding Author: Stephen (Steve) Richardson, Environmental Health Scientist, Agency for Toxic Substances and Dis-

FIGURE 2

Location of Residential Areas Near the Pearce Creek Dredged Material Containment Area (DMCA) to Be Serviced by the Town of Cecilton Municipal Water System



Source: www.pearcecreekoutreach.com/Images/WaterSystem/map.jpg.

ease Registry, Division of Community Health Investigations, Eastern Branch.
E-mail: gol8@cdc.gov.

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Jill M. Shugart,
MSPH, REHS, CP-FS

Utilizing the Emergency Responder Health Monitoring and Surveillance System to Prepare for and Respond to Emergencies

Editor's Note: NEHA strives to provide up-to-date and relevant information on environmental health and to build partnerships in the profession. In pursuit of these goals, we feature a column from the Environmental Health Services Branch (EHSB) of the Centers for Disease Control and Prevention (CDC) in every issue of the *Journal*.

In these columns, EHSB and guest authors share insights and information about environmental health programs, trends, issues, and resources. The conclusions in this column are those of the author(s) and do not necessarily represent the official position of CDC.

CDR Jill Shugart is a senior environmental health specialist and the Emergency Responder Health Monitoring and Surveillance System coordinator for the National Institute for Occupational Safety and Health, Emergency Preparedness and Response Office in Atlanta, Georgia.

During the World Trade Center attack on September 11, 2001, hundreds of thousands of people were exposed to environmental contaminants and traumatic injuries, and nearly 3,000 people lost their lives (Lucchini et al., 2017). As workers from every U.S. state rushed in to help those affected, there was minimal health tracking of workers and records of what they were exposed to or what type of personal protective equipment they may have been wearing early in the response. As a result, 450 workers died and hundreds more were seriously injured (Jackson et al., 2002).

In order to ensure workers can respond safely and effectively to future emergencies, the National Institute for Occupational Safety and Health (NIOSH) collaborated with federal agencies, state health departments, and

unions to create the Emergency Responder Health Monitoring and Surveillance (ERHMS) System. ERHMS is a framework that allows an organization to monitor the health and safety of emergency responders throughout the predeployment, deployment, and post-deployment phases of a response. The goal of ERHMS is to prevent short- and long-term illness and injury in emergency responders. Traditional groups of workers that typically respond to emergencies include police, fire, emergency medical personnel, and construction and utility workers, but can also include environmental health specialists, industrial hygienists, mental health professionals, and other public health personnel and volunteers.

There are well documented gaps and deficiencies in the health monitoring and surveillance of emergency response workers in

reports following the 9/11 terrorist attacks (Jackson, Baker, Ridgeley, Bartis, & Linn, 2004), but unfortunately, these trends have continued during the responses to Hurricanes Katrina and Rita (Bergan, Thomas, Schwartz, McKibbin, & Rusiecki, 2015; Rusiecki et al., 2014) and Deepwater Horizon (Kitt et al., 2011; National Institute for Occupational Safety and Health, 2011).

ERHMS aims to ensure specific activities to protect the health and safety of emergency response and recovery workers are conducted during each of the three phases of a response (Figure 1). During the predeployment phase, organizations should ensure workers are properly rostered, credentialed and trained; fit for duty; and can store this information in a secure manner. During the deployment phase, health monitoring and surveillance should be conducted while workers perform their job tasks to ensure there are no exposures. This monitoring includes making sure workers have access to potable water, safe food, and secure housing. During the postdeployment phase, workers should be properly demobilized and it should be determined if long-term tracking is needed. After action meetings should be conducted and lessons learned documented to continually improve future responses. The guidance for how to implement these activities and specific tools that can be utilized during each phase of the response can be found in the National Response Team (NRT) Technical Assistance Document (NRT, 2012).

There is evidence that ERHMS can be implemented by organizations. For example, during the 2014 Ebola outbreak, NIOSH

FIGURE 1

Three Phases of the Emergency Responder Health Monitoring and Surveillance System



For More Information

- Visit the Emergency Responder Health Monitoring and Surveillance (ERHMS) website at www.cdc.gov/niosh/erhms
 - View ERHMS training opportunities
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assisted the Centers for Disease Control and Prevention (CDC) with expanding its Responder Readiness Program by implementing the ERHMS framework into their response structure. Specifically, a pre-deployment coordinator position was established to work with responders before they deployed to ensure they met all the health requirements and were properly trained. Several NIOSH staff served as safety officers in affected countries in order to conduct health and safety monitoring of staff during the deployment phase. Finally, a postdeployment coordinator position was created to determine if any long-term monitoring should be conducted, including any mental health needs.

In 2016, as Hurricane Matthew was fast approaching, the Georgia Department of Public Health (DPH) adapted their existing Responder Safety, Tracking, and Resilience

(R-STAR) System to incorporate ERHMS. DPH staff sent out surveys to responders to self-register their deployment activities and to complete a health and safety check. According to Funk (2017), feedback from participants indicated responders valued someone checking in on them during their deployment and supervisors could verify their responders were accounted for and unharmed. By incorporating ERHMS, DPH would be able to meet Capability 14 (responder safety and health) as part of its CDC Public Health Emergency Preparedness cooperative agreement (CDC, 2011). Any state receiving this funding can implement ERHMS by completing tasks in Capability 14 or 15 (volunteer management).

In order to increase an organizations' ability to implement and adopt ERHMS, NIOSH has recently developed ERHMS Info Manager,

a free, custom-built software product that uses Epi Info for all calculations and analyses. This product allows for the collection of data as outlined in ERHMS throughout all three phases of a response. For example, ERHMS Info Manager will allow users to manage staff readiness by collecting information on rostering, training, and medical screening, thus improving organization preparedness prior to an emergency. NIOSH has also developed a user manual and training videos to accompany the software and has partnered with Epi Info to ensure technical support is available to all users. In addition, NIOSH has free training on ERHMS available online and in-person. Continuing education credits are available for these trainings.

With an increase in emerging threats over the past several years and a high demand for environmental public health and safety professionals to respond, it is imperative that we continue to train our workers to prepare for and respond to emergencies. Without a trained, well-equipped, and healthy workforce, we cannot overcome future threats. 🚒

Corresponding Author: Jill M. Shugart, Emergency Preparedness and Response Office, National Institute for Occupational Safety and Health/Centers for Disease Control and Prevention, 1600 Clifton Road, MS E-20, Atlanta, GA 30329. E-mail: jshugart@cdc.gov.

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NEHA is partnering with the U.S. Department of Housing and Urban Development (HUD) and the Office of Lead Hazard Control and Healthy Homes for the NEHA 2018 AEC and HUD Healthy Homes Conference. Learn more at www.neha.org/aec.



2018 Joe Beck Educational Contribution Award

This award was established to recognize NEHA members, teams, or organizations for an outstanding educational contribution within the field of environmental health.

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To access the online application, visit www.neha.org/about-neha/awards/joe-beck-educational-contribution-award.





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July 8–11, 2019: NEHA 2019 Annual Educational Conference & Exhibition, Nashville, TN.

July 13–16, 2020: NEHA 2020 Annual Educational Conference & Exhibition, New York, NY.

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July 24–27, 2018: Annual Education Meeting, hosted by the Florida Environmental Health Association, Cape Canaveral, FL. For more information, visit www.feha.org.

Michigan

March 21–23, 2018: Annual Education Conference, hosted by the Michigan Environmental Health Association, Pontiac, MI. For more information, visit www.meha.net/AEC.

Ohio

April 17–18, 2018: 72nd Annual Education Conference, hosted by the Ohio Environmental Health Association, Worthington, OH. For more information, visit www.ohioeha.org.

Utah

May 2–4, 2018: Spring Conference, hosted by the Utah Environmental Health Association, Vernal, UT. For more information, visit www.ueha.org/events.html.

Washington

May 7–9, 2018: 66th Annual Educational Conference—Environmental Public Health: Partnering, Protecting, & Planning, hosted by the Washington State Environmental Health Association, Olympia, WA. For more information, visit www.wseha.org.

TOPICAL LISTING

Food Safety and Protection

November 6–9, 2017: Integrated Foodborne Outbreak Response and Management (InFORM) 2017 Conference, Garden Grove, CA. For more information, visit www.aphl.org/conferences/InformConf/Pages/default.aspx.

Public Health

April 10–11, 2018: Iowa Governor's Conference on Public Health, Des Moines, IA. For more information, visit www.ieha.net/IGCPH. 🐾

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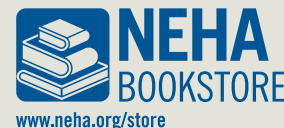


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Certified Professional–Food Safety Manual (Third Edition)

National Environmental Health Association (2014)



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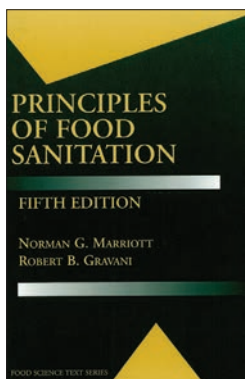
active managerial control, cleaning and sanitizing, conducting facility plan reviews, pest control, risk-based inspections, sampling food for laboratory analysis, food defense, responding to food emergencies and foodborne illness outbreaks, and legal aspects of food safety.

358 pages / Spiral-bound paperback

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Principles of Food Sanitation (Fifth Edition)

Norman G. Marriott and Robert B. Gravani (2006)



This book provides sanitation information needed to ensure hygienic practices and safe food for food industry and regulatory professionals. It addresses the principles related to contamination, cleaning compounds, sanitizing, and cleaning equipment. It also presents specific directions for applying these concepts to attain hygienic conditions in food processing or preparation operations. The book includes chapters that address biosecurity and allergens as they relate

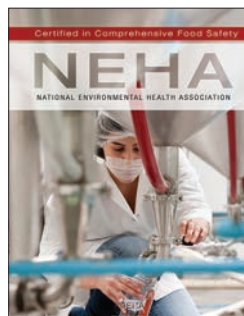
to food sanitation, as well as updated chapters on the fundamentals of food sanitation, contamination sources and hygiene, HACCP, cleaning and sanitizing equipment, and waste handling disposal. Study reference for NEHA's Registered Environmental Health Specialist/Registered Sanitarian and Certified Professional–Food Safety credential exams.

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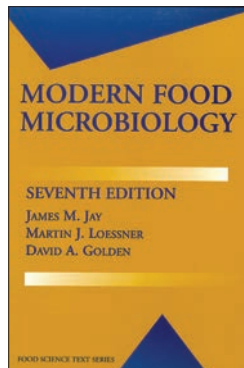
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James M. Jay, Martin J. Loessner, and David A. Golden (2005)



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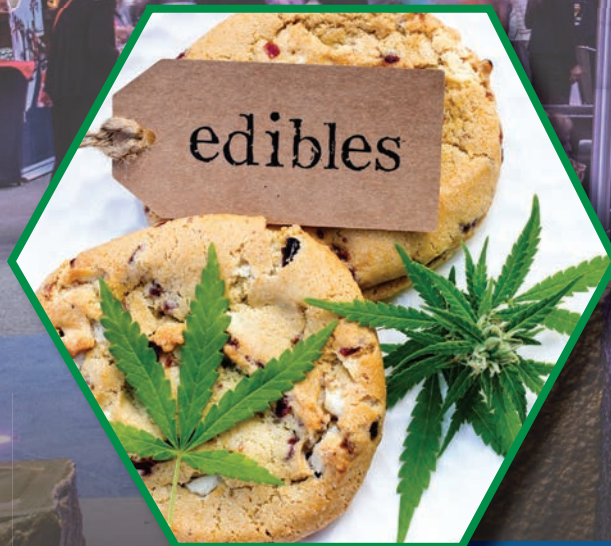


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deejaylebeau@verizon.net

South Carolina—Melissa Tyler, Environmental Health Manager II, SCDHEC, Cope, SC.
tylermb@dhec.sc.gov

South Dakota—John Osburn, Pierre, SD.
john.osburn@state.sd.us

Tennessee—Eric L. Coffey, Chattanooga, TN.
tehapresident@gmail.com

Texas—Victor Baldovinos, Environmental Health Director, City of South Padre Island, TX.
vbaldovinos@myspi.org

Uniformed Services—MAJ Sean Beeman, MPH, REHS, CPH, Colorado Springs, CO.
sean.p.beeman.mil@mail.mil

Utah—Phil Bondurant, MPH, Director of Environmental Health, Summit County Health Dept., Heber City, NV.
pbondurant@summitcounty.org

Virginia—David Fridley, Environmental Health Supervisor, Virginia Dept. of Health, Lancaster, VA.
david.fridley@virginiaeha.org

Washington—Joe Graham, Washington State Dept. of Health, Olympia, WA.
joe.graham@doh.wa.gov

West Virginia—Brad Cochran, Charleston, WV.
brad.j.cochran@wv.gov

Wisconsin—Sonja Dimitrijevic, Dept. of Agriculture, Trade, and Consumer Protection, WI.
sonja.dimitrijevic@wisconsin.gov

Wyoming—Todd Denny, Basin, WY.
todd.denny@wyo.gov

Technical Advisors

Air Quality—Vacant

Aquatic Health/Recreational Health—Tracynda Davis, MPH, Davis Strategic Consulting, LLC.
tracynda@yahoo.com

Aquatic Health/Recreational Health—CDR Jasen Kunz, MPH, REHS, USPHS, CDC/NCEH.
izk0@cdc.gov

Built Environment and Land Use—Kari Sasportas, MSW, MPH, REHS/RS, Cambridge Public Health Dept.
ksasportas@challiance.org

Built Environment and Land Use—Robert Washam, MPH, RS.
b_washam@hotmail.com

Children's Environmental Health—Anna Jeng, MS, ScD, Old Dominion University.
hjeng@odu.edu

Climate Change—Richard Valentine, Salt Lake County Health Dept.
rvalentine@slco.org

Drinking Water/Environmental Water Quality—Craig Gilbertson, Minnesota Dept. of Health.
craig.gilbertson@state.mn.us

Drinking Water/Environmental Water Quality—Maureen Pepper, Drinking Water Program, Idaho Dept. of Environmental Quality.
maureen.pepper@deq.idaho.gov

Emergency Preparedness and Response—Marcy Barnett, MA, MS, REHS, California Dept. of Public Health, Center for Environmental Health.
marcy.barnett@cdph.ca.gov

Emergency Preparedness and Response—Martin Kalis, CDC.
mkalis@cdc.gov

Food (including Safety and Defense)—Eric Bradley, MPH, REHS, CP-FS, DAAS, Scott County Health Dept.
eric.bradley@scottcountyiowa.com

Food (including Safety and Defense)—John Marcello, CP-FS, REHS, FDA.
john.marcello@fda.hhs.gov

General Environmental Health—Tara Gurge, Needham Health Dept.
tgurge@needhamma.gov

General Environmental Health—Cynthia McOliver, National Center for Environmental Research, Office of Research and Development, U.S. EPA.
mcoliver.cynthia@epa.gov

Hazardous Materials/Toxic Substances—Crispin Pierce, PhD, University of Wisconsin-Eau Claire.
piercech@uwec.edu

Healthy Homes and Housing—Judeth Luong, City of Long Beach Health Dept.
judeth.luong@longbeach.gov

Industry—Nicole Grisham, University of Colorado.
nicole.grisham@colorado.edu

Informatics and Technology—Darryl Booth, MPA, Accela.
dbooth@accela.com

Injury Prevention—Alan Dellapenna, RS, North Carolina Division of Public Health.
alan.dellapenna@dhhs.nc.gov

Institutions—Robert W. Powitz, MPH, PhD, RS, CP-FS, R.W. Powitz & Associates, PC.
powitz@sanitarian.com

International Environmental Health—Sylvanus Thompson, PhD, CPHI(C), Toronto Public Health.
sthomps@toronto.ca

Occupational Health/Safety—Tracy Zontek, PhD, Western Carolina University.
zontek@email.wcu.edu

Onsite Wastewater—Sara Simmonds, Kent County Health Dept.
sara.simmonds@kentcountymi.gov

Radiation/Radon—Bob Uhrlik, South Brunswick Township.
ruhrlik@sbtnj.net

Risk Assessment—Jason Marion, PhD, Eastern Kentucky University.
jason.marion@eku.edu

Schools—Stephan Ruckman, Worthington City Schools.
mphosu@yahoo.com

Sustainability—Tim Murphy, PhD, REHS/RS, DAAS, The University of Findlay.
murphy@findlay.edu

Vector Control/Zoonotic Disease Control—Steven Ault, PAHO/WHO (retired).
aultstev@hotmail.com

Vector Control/Zoonotic Disease Control—Tyler Zerwekh, MPH, DrPH, REHS, Shelby County Health Dept.
tyler.zerwekh@shelbycountytg.gov

Workforce Development, Management, and Leadership—Elizabeth Jarpe-Ratner, MidAmerica Center for Public Health Practice, University of Illinois at Chicago.
ejarpe2@uic.edu

NEHA Staff: (303) 756-9090

Seth Arends, Graphic Artist, NEHA Entrepreneurial Zone (EZ), ext. 318, sarends@neha.org

Jonna Ashley, Association Membership Manager, ext. 336, jashley@neha.org

Rance Baker, Program Administrator, NEHA EZ, ext. 306, rbaker@neha.org

Trisha Bramwell, Sales and Training Support, NEHA EZ, ext. 340, tbramwell@neha.org

Vanessa DeArman, Project Coordinator, Program and Partnership Development (PPD), ext. 311, vdearman@neha.org

Kristie Denbrock, Education Coordinator, ext. 313, kdenbrock@neha.org

David Dyjack, Executive Director, ext. 301, ddyjack@neha.org

Santiago Ezcurrea, Media Production Specialist, NEHA EZ, ext. 342, sezcurrea@neha.org

Eric Fife, Learning Media Manager, NEHA EZ, ext. 344, efife@neha.org

Soni Fink, Strategic Sales Coordinator, ext. 314, sfink@neha.org

Nancy Finney, Technical Editor, NEHA EZ, ext. 326, nfinney@neha.org

Michael Gallagher, Operations and Logistics Planner, NEHA EZ, ext. 343, mgallagher@neha.org

TJay Gerber, Credentialing Coordinator, ext. 328, tgerber@neha.org

Arwa Hurley, Website and Digital Media Specialist, ext. 327, ahurley@neha.org

Faye Koeltzow, Business Analyst, ext. 302, fkoeltzow@neha.org

Elizabeth Landeen, Associate Director, PPD, (702) 802-3924, elandeen@neha.org

Matt Lieber, Database Administrator, ext. 325, mlieber@neha.org

Bobby Medina, Credentialing Dept. Customer Service Coordinator, ext. 310, bmedina@neha.org

Marissa Mills, Human Resources Manager, ext. 304, mmills@neha.org

Eileen Neison, Credentialing Specialist, ext. 339, eiseison@neha.org

Carol Newlin, Credentialing Specialist, ext. 337, cnewlin@neha.org

Christine Ortiz Gumina, Project Coordinator, PPD, cortizgumina@neha.org

Solly Poprish, Program Coordinator, PPD, ext. 335, spoprish@neha.org

Barry Porter, Financial Coordinator, ext. 308, bporter@neha.org

Kristen Ruby-Cisneros, Managing Editor, *Journal of Environmental Health*, ext. 341, kruby@neha.org

Christl Tate, Program Manager, PPD, ext. 305, ctate@neha.org

Sharon Unkart, Instructional Designer, NEHA EZ, ext. 317, sdunkart@neha.org

Gail Vail, Director, Finance, ext. 309, gvail@neha.org

Sandra Whitehead, Director, PPD, swhitehead@neha.org

Joanne Zurcher, Director, Government Affairs, jzurcher@neha.org

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**National Environmental Health Association
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 Editor (Name and complete mailing address):
**Kristen Ruby-Cisneros, National Environmental Health Association
 720 S. Colorado Blvd., Ste. 1000-N, Denver, CO 80246-1926**
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adolfo.rosales@ecolab.com

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Macomb County Health Department
jarrod.murphy@macombgov.org

Marathon County Health Department
www.co.marathon.wi.us/Departments/HealthDepartment.aspx

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www.waco-texas.com/cms-healthdepartment

Waukesha County Environmental Health Division
www.waukeshacounty.gov/environmental_health

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University of Georgia, College of Public Health
www.publichealth.uga.edu

University of Washington, Department of Environmental & Occupational Health Sciences
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www.uhs.wisc.edu

University of Wisconsin-Oshkosh, Lifelong Learning & Community Engagement
www.uwosh.edu/lfce

University of Wisconsin-Stout, College of Science, Technology, Engineering, and Mathematics
www.uwstout.edu 

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We would like to thank and honor the individuals listed below who have been members of the association for 25 years or longer. We sincerely appreciate their commitment to the association and the environmental health profession.

a

Warren Abrahams

Accela

Adesegun A. Adefuye

Karen L. Ahrendt

Anthony C. Aiken

Tunde M. Akinmoladun

Thomas J. Anderson

Peter R. Andrews

Louis E. Anello

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b

Dale A. Baker

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d

Richard A. Daugherty

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Daniel De La Rosa

Nancy E. Deal

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Bernard A. Dreher
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Diane R. Eastman
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Brian P. Emanuel
Christopher C. Etcheson
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f

Wendy L. Fanaselle
Saba F. Fattaleh
Frank S. Ferro
LuAnn M. Ford
Morris V. Forsting
Thomas M. Frank
David P. Franken
Norman Franks
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g

Frank A. Gabrian
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Scott R. Golberg
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h

Michael G. Halko
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Jack B. Hatlen
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i

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k

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James P. LaFleur
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Scott L. Maass
Arthur N. Mabbett
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NEHA NEWS

Call for Nominations

By Faye Koeltzow (fkoeltzow@neha.org)

NEHA is governed by a corporate board of directors that oversees the affairs of the association. There will be four board positions up for election in 2018:

- Region 2 vice-president (represents Arizona, California, Hawaii, and Nevada; 3-year term);
- Region 3 vice-president (represents Colorado, Montana, Utah, Wyoming, and members residing outside of the U.S. [except members of the U.S. armed forces]; 3-year term);
- Region 8 vice-president (represents Delaware, Maryland, Pennsylvania, Virginia, Washington, DC, West Virginia, and members of the U.S. armed forces residing outside of the U.S.; 3-year term); and
- second vice-president (national officer; 5-year term that progresses through the national offices and will serve as NEHA president in 2021–2022).

We seek diversity on the board in terms of gender, ethnicity, and a balance between regulatory, academia, and industry professionals. Most importantly, we want people who will help us develop a new strategic vision, have experience managing diverse organizations, and can open doors for NEHA in building relationships with industry, academia, federal and state agencies, foundations, and other associations.

Requirements to serve on the board include

- membership with NEHA (individual or life) for three consecutive years prior to assuming office on June 28, 2018;
- not simultaneously holding a voting position on the board of a NEHA affiliate;
- endorsement by at least five voting NEHA members (from members residing in the region for regional vice-president candidates and from members residing in at least three different regions for second vice-president candidates); and
- willingness to commit the time necessary to actively serve on the board.

If you are interested in serving on our board of directors, please visit www.neha.org/about-neha/governance/elections for information on the nomination and election process. You can also contact NEHA Past-President Bob Custard, chairman of NEHA's Nominations Committee, at bobcustard@comcast.net. The deadline to submit a nomination is **December 1, 2017**.

NEHA Staff Profile

As part of tradition, NEHA features new staff members in the *Journal* around the time of their one-year anniversary. These profiles give you an opportunity to get to know the NEHA staff better and to learn more about the great programs and activities going on in your association. This month we are pleased to introduce you to one NEHA staff member. Contact information for all NEHA staff can be found on page 53.

**Gail Vail**

I love my role as NEHA's finance director! I have the amazing opportunity to be involved with all the finance, accounting, personnel, and computerized management systems so the rest of our team can serve everyone around the country and further our mission.

I am a certified public accountant (CPA) and a chartered global management accountant (CGMA). Before joining NEHA a year ago, I was the controller of the Colorado Society of Certified Public Accountants (COCPA) and worked there for 12 years. COCPA is a similar membership association compared to NEHA, so I have been able to transfer quite a bit of knowledge and experience to my current position. Before COCPA, I worked overseas in Nairobi, Kenya, and East Africa as finance manager for World Concern, a relief and development organization. While there I witnessed extreme environmental health issues that impacted so many. Those experiences have helped fuel my passion for our mission. Prior to my work in Africa, I was the state and local tax manager for a Fortune 500 company in Alabama.

I grew up in Alabama and attended the University of Alabama in Tuscaloosa. Married for 22 years, I met my husband, who is from the U.S., in Kenya! We have one daughter who is in college. A cute Bichon Frise dog rounds out our family. I love running and am part of a local running club. We also love hiking in our Colorado mountains. 🏞️

Did You Know?

You can find a listing of NEHA's leadership at www.neha.org/about-neha/leadership. NEHA's board is made up of five national officers and nine regional vice-presidents. A listing of NEHA staff can be viewed at www.neha.org/about-neha/staff.

DiracTalk

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or Netflix. If I am offered a better deal elsewhere, I will go easily. The relationship that associations garner with their members is something different.

NEHA is not in the business of selling. We are in the business of connecting and working toward a common purpose, which can never be fully analyzed on a return on investment (ROI) calculator. I cannot tell you how much money I have saved over the years by being a member of the associations I am affiliated with. What I can tell you are the names of the people I have met through these associations who I consider to be my collaborators and my community.

To that end, it is my goal as NEHA's membership manager to create or strengthen channels for environmental health professionals to connect. I will be looking at ways for you, as members, to find each other, share ideas, and ultimately, be strengthened in your unity. Some of these channels will be virtual, such as an online member directory, enabling you to seek each other out across the country and internationally. Some channels will be good old fashioned face-to-face interaction, such as developing programs and events for students and young professionals to connect at our Annual Educational Conference & Exhibition. I also hope to facilitate these vital face-to-face interactions through strengthening NEHA's affiliates so that members have more opportunities to establish robust local networks.

My aim is to increase the number of NEHA members so that we can be, as Alexis de Tocqueville wrote, "a power that speaks, and to which one listens." I believe that associations are uniquely suited for this job as long as we can demonstrate our true value. That value will not be defined in business terms like ROI or dues revenue, but in uniting members so they might find their tribe.

My intention is not to take on NEHA membership in isolation. I would like to hear your recommendations and thoughts about creating something I found so long ago, a place to find support, advice, and yes, even friendship. Please reach out to me at jashley@neha.org. 🐘

Did You Know?

The holiday season is coming up! Please note that NEHA's office will be closed for Thanksgiving on November 23 and 24. The office will be closed for the holidays on December 25–January 1. If you have any end-of-the-year business with us, make sure to contact us prior to December 25.

2018

ACCEPTING NOMINATIONS NOW

Walter S. Mangold Award

The Walter S. Mangold Award recognizes an individual for extraordinary achievement in environmental health. Since 1956, this award acknowledges the brightest and best in the profession. NEHA is currently accepting nominations for this award by an affiliate in good standing or by any five NEHA members, regardless of their affiliation.

The Mangold is NEHA's most prestigious award and while it recognizes an individual, it also honors an entire profession for its skill, knowledge, and commitment to public health.

**Nomination deadline is
March 15, 2018.**



To access the online application, visit www.neha.org/about-neha/awards/walter-s-mangold-award.

► **DirecTalk** MUSINGS FROM THE 10TH FLOOR

David Dyjack, DrPH, CIH

I'm delighted to formally introduce you to Jonna Ashley, NEHA's new membership manager. Jonna's fingerprints are quickly being felt throughout the organization as we strive to become the most essential and influential environmental health association in the world. Her aim to "create or strengthen channels for environmental health professionals to connect" will be a central feature of our efforts going forward.

Dave

ddyjack@neha.org
Twitter: @DTDyjack

I joined my first association when I was 23 years old. A recent college graduate and living by myself in Washington, DC, I was looking to build a professional network and add some real-world experience to my meager résumé. What I found was a group of people who provided not only professional opportunities but also support, advice, and even friendship. I found my tribe.

It was this group of people who bolstered me when I wanted to do the unthinkable and start a new career at the onset of the 2008 recession. It was this group that gave me my first encounters with event planning, marketing, and most significantly, membership. These connections and opportunities happened in meeting rooms and through social media. They also took place over dinners and impromptu happy hours after long days at work. In some of these connections I played the role of the mentor and in others I was

What Is the Value of Membership?

I believe that the true value of membership is in finding a group of people who understand how you spend your days and encourage you to seek growth.

a sponge absorbing knowledge and experiences. Each connection, however, created value. These interactions made me a better person and a better advocate for my industry.

Since joining that first association, the Women's Information Network, I have gone on to participate in several other professional and cause-based associations as a member, a volunteer, and an employee. I have come to believe that the true value of membership is in finding a group of people who understand how you spend your days and encourage you to seek growth and further your mission. I believe that we are stronger, and can do more, together. After all, strength in connection is the reason that associations were originally founded.

Alexis de Tocqueville, author of the 1835 book *Democracy in America*, is generally considered the first spokesperson for the work of associations. In his treatise on associations, he states, "As soon as several of the inhabitants of the United States have conceived a sentiment or an idea that they want to produce in the world, they seek each other out; and when they have found each other, they unite. From then on, they are no longer isolated men, but a power one sees from afar, whose actions serve as an example; a power that speaks, and to which one listens."

These days, with improvements in technology and for-profit companies increasing their interest in membership-based business models, it is possible for people to connect and achieve collective action with greater ease. Associations have been challenged to respond strategically, particularly in the area of membership, where they are being asked to demonstrate a return on dues investment.

I can easily display the positive return on investment for NEHA membership dues, but that falls short of revealing the true value of membership. When we go down the road of operating association membership like a business, seeing our members as customers who we need to attach sales metrics to, we miss the mark on what it means to be a member of a professional association. Amazon has members. Netflix has members. If I feel that I have saved money or time using these services, I will happily renew for another year, but I have no stake or alliance to Amazon

continued on page 61

Inspect2GOTM

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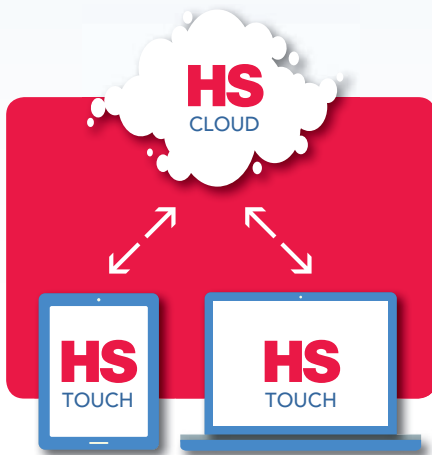
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The image displays the Inspect2GO software interface. On the left is a desktop dashboard with a sidebar menu containing: Dashboard, Scheduler, Forms, Inspections, Food, Sewage, Well, Pool, Child Care, Complaints, Permitting, Accounting, and Reports. The main dashboard area shows '22 Users' and '823 Food Inspections (past 30 days)' with a pie chart. On the right, a tablet shows the mobile app interface for a location at 533 Maple Ave., Irvine, CA 92673. The app screen lists inspection items with status buttons (IN, OUT, N/A, R, N/O, COS) and a camera icon. A temperature sensor is overlaid on the screen, showing a reading of 68.6 degrees.

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Hazardous Chemical Releases Occurring in School Settings, 14 States, 2008–2013

Ayana R. Anderson, MPH
Agency for Toxic Substances and Disease Registry

Taniece R. Eure, MPH
University of Georgia College of Public Health

Maureen F. Orr, MS
Agency for Toxic Substances and Disease Registry

Lloyd J. Kolbe, PhD
Indiana University Bloomington School of Public Health

Alan Woolf, MPH, MD
Harvard Medical School

Abstract Children are considered to be a vulnerable population when it comes to exposures to hazardous substances. Schools, where children spend about one third of their day, are expected to be a safe environment. Yet, there are many hazardous substances in schools that can be inadvertently or intentionally released and harm the health of students and teachers alike. The purpose of this analysis is to characterize acute chemical release incidents in school settings and identify prevention practices.

The acute chemical incident surveillance programs of the Agency for Toxic Substances and Disease Registry (ATSDR) captured 24,748 acute chemical release incidents from 14 states that participated during 2008–2013. We examined 335 of these incidents that occurred at schools. While only 1.3% ($n = 335$) of all chemical incidents reported to ATSDR occurred in schools, these incidents represented a larger part of the total impacts, including 8.5% of incidents with persons injured, 5.7% of evacuations ordered, and 31.1% of people evacuated. Natural gas (21.8%) and mercury (18.2%) were the chemicals most frequently released.

Collecting and analyzing data on acute school chemical releases allows stakeholders to target prevention initiatives and provide a school environment safe from these chemical exposures.

Introduction

According to the National Center for Education Statistics, approximately 54 million students attended 116,240 public and private elementary and secondary schools within the U.S. during the 2011–2012 school year (Bitterman, Gray, & Goldring, 2013). Children spend about one third of their day in school, where they should be provided a healthy learning environment. Many factors, however, can lead to substandard environmental conditions in schools, which can result in serious

health problems for students (U.S. Environmental Protection Agency [U.S. EPA], 2017a), as well as for school employees. School buildings contain chemicals of varying toxicity for sanitation, pest control, and for educational purposes, such as supplies in science laboratories, art classrooms, automotive repair areas, and vocational arts workshops (Berkowitz, Haugh, Orr, & Kaye, 2002).

Children are inherently more susceptible and vulnerable to many environmental hazards because of their developing bodies and

age-associated behaviors (U.S. EPA, 2017a). Studies have shown that student exposure to hazardous chemicals in schools can result in poor academic performance, respiratory issues, and increases in school absenteeism (U.S. EPA, 2017a). Along with the physical and cognitive hazards to children, acute chemical releases in schools impose enormous financial and economic hardships on schools and communities. Remediation, teachers' lost work time, and evacuations can be extremely costly. For example, a school mercury incident in Texas required approximately \$900,000 to test and cleanup all of the school's 137,000 square feet (Blaney, 2014), while another incident in Alabama required a 2-week, \$517,247 cleanup (Leech, 2013).

News media outlets sometimes report acute hazardous chemical releases in schools. Outside of media reports, however, no single system is responsible for capturing all school chemical releases in the U.S. Therefore, quantifying or characterizing the nature of the incidents and their public health impacts is difficult. To better understand acute chemical incidents at schools and their public health impacts, we analyzed data from the 14 states that participated in the Agency for Toxic Substances and Disease Registry (ATSDR) Hazardous Substances Emergency Events Surveillance (HSEES) system and the National Toxic Substance Incidents Program (NTSIP).

Methods

Our analysis reviewed ATSDR's HSEES (2008–2009) and NTSIP (2010–2013) data. During various periods within this time frame, a total of 14 states participated (Colorado, Florida, Iowa, Louisiana, Michigan, Minnesota, New York, North Carolina, Ore-

TABLE 1

Summary of School Chemical Incidents Compared With Nonschool Incidents, Hazardous Substances Emergency Event Surveillance/National Toxic Substance Incidents Program, 2008–2013

Category	School Chemical Incidents	Nonschool Incidents	Total
Incidents	335	24,413	24,748
Evacuations ordered	192 (57.3%)	3,171 (13.0%)	3,363 (13.6%)
Total people evacuated ^a	47,433	104,985	152,418
Median number of people evacuated (range)	305 (2–3,000 evacuees/incident)	17 (1–15,000 evacuees/incident)	20 (1–15,000 evacuees/incidents)
Total evacuation hours ^b	2,689	17,145	19,834
Median hours of evacuations (range)	2 (15 min–1,392 hr)	2 (15 min–2,664 hr)	2 (15 min–2,664 hr)
Incidents with injured persons	119 (35.5%)	3,173 (13.0%)	3,292 (13.3%)
Injured persons	712	7,644	8,356
Median number of injured persons (range)	2 (1–61 injured persons/incident)	1 (1–54 injured persons/incident)	1 (1–61 injured persons/incident)

^aNumber indicates the number of known evacuees. When large areas were evacuated, not all evacuees could be counted, so the number for evacuees is an underestimate.

^bNumber indicates the reported time frame for evacuations (reported to the nearest quarter hour). Not all incidents that reported evacuations included time frame of evacuation, so total hours of evacuations is an underestimate.

gon, Tennessee, Texas, Utah, Washington, and Wisconsin). From 1990–2009, HSEES was a state-based surveillance system used to track the public health impacts of hazardous substance releases (e.g., morbidity, mortality). NTSIP began in 2010 and continued with hazardous substance releases tracking and added a national component and mass incident investigations component (for more information about the HSEES program, please go to www.atsdr.cdc.gov/HS/hsees/Public_Use_File.html and for NTSIP, please go to www.atsdr.cdc.gov/ntsip).

Surveillance states used various data reporting sources, including state and local environmental protection agencies, police and fire departments, poison control centers, hospitals, local media, and various federal databases (e.g., U.S. Department of Transportation's Hazardous Materials Incident Reporting Systems and U.S. Coast Guard's National Response Center) to collect data on incidents, which was then entered into a secure web-based application.

A major difference in case definition between the two databases is that petroleum (natural gas, crude oil, etc.) incidents were excluded from HSEES unless another hazardous substance was also released; petroleum incidents were included in NTSIP if

there was a public health impact such as an evacuation or injury (Agency for Toxic Substances and Disease Registry [ATSDR], 2016b). To identify releases that occurred in school settings (school chemical releases), we used the North American Industry Classification System (NAICS) code number 6111, which included both elementary and secondary schools and manually reviewed the comments and synopsis sections in the HSEES/NTSIP databases to verify that the incidents occurred in elementary or secondary schools.

We performed descriptive analysis of the data using SAS version 9.2.

Results

A total of 24,748 chemical incidents (that included multiple and single chemical releases) were captured during the 6-year (2008–2013) surveillance period. Only 1.3% ($n = 335$) of incidents occurred at schools, 57.3% ($n = 192$) of these incidents resulted in 47,433 persons evacuated (median = 305 persons) (Table 1). The range of hours for evacuations was 15 min to 1,392 hr (median = 2 hr). Only one incident reported an evacuation that lasted 56 days and 18 hr (1,392 hr). This incident occurred in an elementary school where mercury was released in a classroom. A beaker

fell from a student's hand and released mercury. Students were moved to another room. A hazmat team was called; access to the classroom where the incident occurred and a section of the adjacent hallway was restricted and ventilation was shut down.

As a comparison, even though over half (57.3%) of school chemical incidents resulted in an evacuation being ordered, nonschool incidents had a lower percentage of evacuations (13%). The lower percentage of nonschool evacuations could be because there were more nonschool incidents reported than school chemical releases. There was one incident, however, that led to an evacuation that lasted 111 days (2,664 hr). This single incident was a gas release that occurred in a private residence.

The public health actions that took place after many of the school chemical incidents included environmental sampling ($n = 129$ incidents), health investigations ($n = 2$ incidents), water intake shutdown ($n = 1$ incident), alternative water provision ($n = 1$ incident), and a health advisory issuance ($n = 1$ incident). The most commonly reported contributing factors for acute school chemical releases were human error (49%), equipment failure (32%), and intentional acts (15%) (Figure 1).

FIGURE 1

Distribution of Contribution Factors That Were Associated With School Chemical Releases, Hazardous Substance Emergency Event Surveillance/National Toxic Substance Incidents Program, 2008–2013 (N = 335)

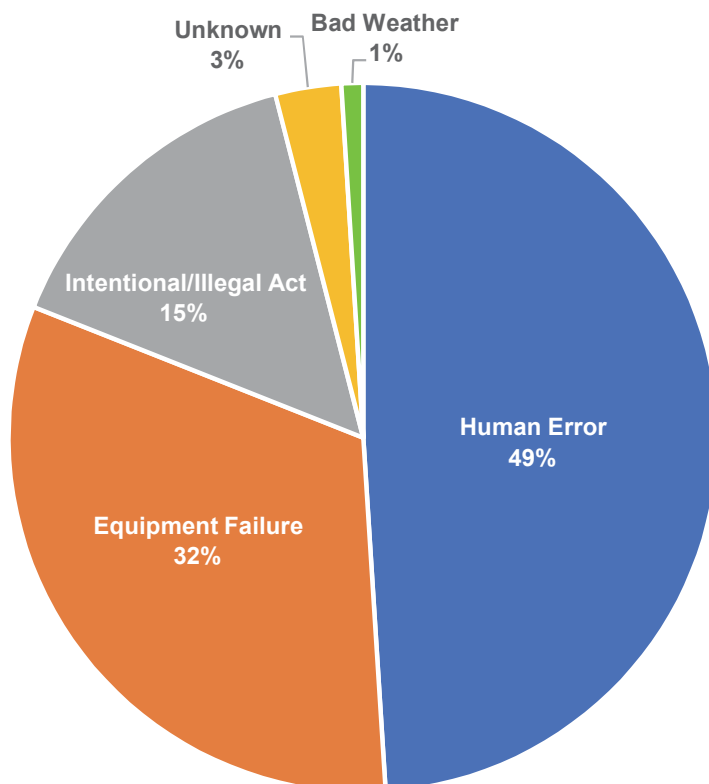


TABLE 2

Summary of Top Five Chemicals Released in School Settings, Hazardous Substance Emergency Event Surveillance/National Toxic Substance Incidents Program, 2008–2013

Substance	Incidents # (%)	Incidents With Evacuations # (%)	Total People Evacuated # (%)	Incidents With Injured Persons # (%)	All Injured Persons # (%)
Overall totals	335	192	47,433	119	712
Natural gas	73 (21.8)	66 (34.4)	13,738 (29.0)	3 (2.5)	3 (0.4)
Mercury	61 (18.2)	32 (16.7)	7,362 (15.5)	3 (2.5)	10 (1.4)
Carbon monoxide	21 (6.3)	16 (8.3)	6,754 (14.2)	7 (5.9)	143 (20.1)
Hydrochloric acid	14 (4.2)	4 (2.1)	650 (1.4)	11 (9.2)	43 (6.0)
Pepper spray	13 (3.9)	8 (4.2)	2,950 (6.2)	10 (8.4)	78 (11.0)

Natural gas, mercury, and carbon monoxide were the most frequently reported chemicals released in schools, accounting for almost one half (46.3%) of all school incidents. These chemicals also accounted for almost 60% of all evacuations ordered and people evacuated (Table 2). Compared with other chemicals, carbon monoxide was associated with the highest percentage of injured persons (20.1%), followed by pepper spray incidents (11%) (Table 2).

Forty-one (12.2%) of the incidents occurred in school laboratories, and over half ($n = 22$) of these were associated with injuries (a total of 88 injured persons). Fourteen (4.2%) incidents involved cleaning/disinfecting chemicals, which were associated with 48 injured persons. Swimming pool chemicals were reported in 12 (3.6%) incidents and were associated with 31 injured persons. Injuries were reported in 119 (35.5%) of the school chemical releases, with a total of 712 injured persons (Table 1).

Students accounted for 62.1% ($n = 442$) of injured persons, and nonstudents (defined as school employees, general public, and responders) accounted for 37.9% ($n = 270$). A majority, 57.3%, of the injured persons ($n = 408$) were treated at a hospital but not admitted, and another 12.5% ($n = 89$) were treated at the scene (Table 3). A total of 1,013 injuries and symptoms were reported for 712 injured persons (Table 3). Respiratory irritation was the most frequently reported injury/symptom for both students (27.8%) and nonstudents (39.9%). Gastrointestinal issues and eye irritation were the second and third most commonly reported injuries/symptoms for students. For nonstudents, eye irritation and headaches were the other most commonly reported injuries/symptoms (Table 3).

Discussion

This article, using HSEES/NTSIP public health surveillance data, describes a series of school chemical releases ($n = 335$) in 14 states. Even though chemical releases in schools represented a relatively small portion (1.3%) of releases in all locations, this report demonstrates that school chemical releases can cause serious public health consequences. A previous 10-year analysis of HSEES data (1999–2008) showed not only a large number of persons injured in educational institutions (NAICS code 6111), but

TABLE 3

Disposition and Symptoms of Injured Persons Comparing Students With Nonstudents in School Chemical Releases, Hazardous Substances Emergency Event Surveillance/National Toxic Substance Incidents Program, 2008–2013

	Students # (%)	Nonstudents ^a # (%)	Total # (%)
Injured person disposition			
Treated at hospital (not admitted)	282 (63.8)	126 (46.7)	408 (57.3)
Treated on scene	62 (14.0)	27 (10.0)	89 (12.5)
Observation at hospital, no treatment	47 (10.6)	4 (1.5)	51 (7.2)
Treated at hospital (admitted) ^b	22 (5.0)	40 (14.8)	62 (8.7)
Treated at hospital (admittance unknown)	17 (3.9)	55 (20.4)	72 (10.1)
Seen by private physician	8 (1.8)	10 (3.7)	18 (2.5)
Injury reported by official	4 (0.9)	8 (2.9)	12 (1.7)
Total	442 (100)	270 (100)	712 (100)
Injury/symptoms type			
Respiratory irritation	174 (27.8)	155 (39.9)	329 (32.5)
Gastrointestinal issues	107 (17.1)	21 (5.4)	128 (12.6)
Eye irritation	98 (15.7)	67 (17.3)	165 (16.3)
Other	59 (9.4)	32 (8.2)	91 (9.0)
Headache	56 (9.0)	33 (8.5)	89 (8.8)
Dizziness/central nervous system issues	54 (8.6)	31 (8.0)	85 (8.4)
Burns	29 (4.6)	23 (5.9)	52 (5.1)
Chemical	23	13	36
Thermal	1	3	4
Both	3	1	4
Unknown	2	6	8
Skin irritation	28 (4.5)	13 (3.4)	41 (4.0)
Shortness of breath	17 (2.7)	4 (1.0)	21 (2.1)
Trauma	3 (0.5)	7 (1.8)	10 (1.0)
Chemical	2	1	3
Nonchemical	0	4	4
Unknown	1	2	3
Heat stress	0 (0)	2 (0.5)	2 (0.2)
Total ^{c,d}	625 (99.9)	388 (99.9)	1,013 (100)

^aNonstudents include employees, general public, and responders.

^bIncludes those who were observed and treated at hospital.

^cSome totals do not equal 100 due to rounding.

^dInjury type numbers may be higher than injured person numbers because some people reported multiple injuries.

also an increasing number of incidents in this sector (Orr, Wu, & Sloop, 2015).

Natural Gas

Natural gas was the most frequently reported chemical released in school settings. Adverse

health effects from natural gas releases can be avoided by quickly establishing a means to detect and stop the release and ensure a rapid and orderly evacuation. Some natural gas incidents are the result of damaging or cutting utility lines due to construction.

To prevent these incidents, workers should obtain information—prior to digging—about the location of underground utility lines and understand the rules and regulations pertaining to digging in certain areas (Common Ground Alliance, 2015).

The telephone number 811 has been nationally designated to eliminate confusion over multiple “Call Before You Dig” numbers across the country. Dialing 811 connects callers with local centers that notify the appropriate local utilities, who send crews to the requested site to mark the approximate location of underground lines at no charge. As natural gas incidents would not have been captured in HSEES unless another hazardous chemical was released at the same time, and only natural gas incidents with a public health impact would be included in NTSIP, the number of school natural gas incidents is likely to be underestimated.

Mercury

Mercury was the second most frequently reported chemical released in school settings. Mercury is found in a variety of products such as fluorescent light bulbs, thermostats, thermometers, barometers, and batteries (ATSDR, 2014). Exposure to mercury can result in adverse health impacts. The central nervous system is the body system most sensitive to exposure to mercury vapor, potentially resulting in memory loss, headache, sleeplessness, irritability, and tremors. Children are at an even higher risk because their nervous systems are still developing (ATSDR, 2011a). Schools can take several steps to mitigate the risk of mercury releases and the potential adverse effects from exposure. First, children and faculty can be educated about the dangers of mercury, especially because its unique properties make it attractive to children to play with. ATSDR has an interactive website called Don't Mess with Mercury for children and teachers. The website has fact sheets, videos, games, and links to other resources that educate children and adults about the dangers of mercury and ways to properly remove mercury from schools (ATSDR, 2016b). In addition to identifying and disposing of mercury compounds and mercury-containing equipment, another way to reduce the potential for releases is by purchasing mercury-free products (U.S. EPA, 2016). Nineteen states have enacted legislation that bans or requires reduction of mercury in

schools, and some states have regulations that restrict selling lamps that contain mercury to schools or that require schools to evaluate the uses of these lamps and seek alternatives.

Carbon Monoxide

Carbon monoxide (CO) was the third most frequently reported chemical released in school settings. To prevent CO releases in school settings, maintenance staff can frequently inspect and provide routine maintenance of vented combustion appliances, and schools can install carbon monoxide detector alarms (Raub, Mathieu-Nolf, Hampson, & Thom, 2000). Rules and regulations requiring CO detectors in schools vary from state to state (National Conference of State Legislatures, 2015). For more guidance about CO safety, schools can refer to the National Fire Protection Association. This organization can provide safety tips for preventing and/or reducing injuries and the severity associated with CO releases. For instance, they discuss the instructions on proper placement of CO alarms and what should be done to maintain CO alarms (National Fire Protection Association, 2017).

Pepper Spray

Chemical releases associated with pepper spray resulted in 78 injured persons. Most pepper spray incidents involved students intentionally releasing the substance (e.g., in pranks or fights). Preventive strategies can educate students about the health effects of pepper spray, including burns to the skin and eyes, coughing, and difficulty breathing (Hurley, 2013). As some pepper spray releases are a result of conflict, school authorities can teach students healthy, nonviolent ways to resolve conflicts with their peers.

Pool Chemicals

Pool chemicals were reported in 12 school chemical releases. The most commonly known pool chemicals are chlorine, hydrochloric/muriatic acid, and hypochlorite. Exposure to pool chemicals can result in serious health impacts, such as respiratory, eye, and skin irritation; gastrointestinal problems; and headaches. A majority of pool chemical releases are a result of human error (e.g., incorrectly adding chemicals to the pool) and equipment failure. Proper training for pool operators can prevent pool chemical releases and injuries

associated with them. Routine maintenance of pool equipment can also help prevent releases and injuries (Anderson, 2015).

School-Based Prevention Strategies

To prevent and mitigate chemical releases in school laboratories, proper training of school administrators, teachers, and other school personnel, as well as adequately supervising students, can be key steps in effectively minimizing exposure (Landrigan et al., 1998). The U.S. Consumer Product Safety and Commission and Centers for Disease Control and Prevention's (CDC) National Institute for Occupational Safety and Health developed a guide to reduce chemical exposures in school laboratories. This guide outlines responsibilities for teachers; safety dos and don'ts for students; and how to safely store, track, and dispose of chemicals and chemical waste from laboratories (U.S. Consumer Product Safety Commission, 2006).

Integrated chemical management (ICM) is an approach that establishes a central location where all laboratory chemicals at schools can be properly inventoried, stored, secured, and controlled (U.S. EPA, 2012). Some chemical releases that occur in school laboratory settings could be the result of spills from outdated and/or unknown chemicals being stored (U.S. EPA, 2011). To help remove outdated, unknown, and potentially harmful chemicals, in 2004 U.S. EPA developed the Schools Chemical Cleanout Campaign (SC3). SC3 is a national strategy that provides tools and resources for schools to use in their chemical cleanout programs (U.S. EPA, 2011).

Cleaning products and disinfectants can contain hazardous chemicals, such as ammonia, hydrochloric acid, and sodium hydroxide. Some acute adverse health effects associated with cleaning products and disinfectants include respiratory and skin irritation, gastrointestinal problems, and burns (Anderson, 2015). To minimize harmful effects, many schools have chosen to eliminate cleaning products with the most toxic ingredients and replace them with environmentally responsible choices. U.S. EPA's Design for the Environment is a program that helps consumers, businesses, and institutional buyers identify cost-efficient and environmentally safer cleaning products and focuses on safely labeling disinfectants. Other certified programs include UL ECOLOGO and Green

Seal, which are independent, third-party certification programs that recommend products that have minimal harmful effects on human health and the environment (U.S. EPA, 2017b; An Act Concerning Green Cleaning Products in Schools, 2009). Currently, 10 states and one district have green cleaning policies and/or recommendations for schools: Connecticut, Hawaii, Illinois, Iowa, Maine, Maryland, Missouri, Nevada, New York, Vermont, and Washington, DC (Environmental Law Institute, 2013). Although these states vary in the ways they establish criteria to implement policies and laws, they all use eco-certification to define green chemicals (ATSDR, 2014).

According to ICM, cleaning chemicals, such as laboratory chemicals, should be stored in a centralized location that is properly equipped with ventilation, security, and lighting for optimal safety. ICM involves a "pharmacy approach" that includes inventorying supplies; removing hazardous, outdated, and unnecessary products; proper labeling and recycling; and ensuring chemical security. The "pharmacy" is under the supervision of an "ICM gatekeeper" who maintains the chemical inventory, orders supplies, and verifies the safe condition of the area (U.S. EPA, 2012). For example, hydrochloric acid can cause eye, nose, and respiratory irritation, as well as heart problems (ATSDR, 2011b). In school settings, exposure to hydrochloric acid can occur in science laboratories and through contact with cleaning chemicals. Practicing ICM, in addition to properly wearing personal protective equipment, can mitigate hydrochloric acid releases and injuries associated with exposure.

Limitations

The HSEES/NTSIP data that were analyzed have some limitations. First, reporting school chemical releases might not be mandatory, so not all school chemical releases were reported to HSEES/NTSIP notification sources, resulting in some underreporting of school chemical releases. Second, with only 14 states represented, HSEES/NTSIP school chemical releases might not be nationally representative. Third, the number of injured persons and evacuations are an underestimation, due to underreporting of incidents. Finally, because of heightened concerns for children's safety, evacuation and transport to medical

facilities might have been more proactive in school chemical releases than similar releases in other locations, which might account for the disproportionately high numbers of reported evacuations and injuries and more frequent medical treatment of school children.

Conclusions

Our report shows that many resources and strategies are available to school administrators to prevent acute hazardous chemical releases. There are other environmental hazards at schools, such as asbestos and mold, which we are not able to address with our data; however, there are other resources available to schools to assist with the physical environment. For example, CDC periodically conducts surveys of policies and practices relevant to the school physical environment in school districts across the U.S. through the School Health Policies and Practices Study (Everett Jones, Smith, Axelrad, & Wendel, 2012). In addition, the U.S. EPA has developed State School Environmental Health Guidelines (U.S. EPA, 2017c), voluntary School Siting Guidelines (U.S. EPA, 2017d), and a Model School Environ-

mental Health Program (U.S. EPA, 2016b) as free resources to improve health and wellness of school students and staff. Also, the U.S. Department of Education has implemented a Green Ribbon Schools award program, another resource for enhancing health and wellness in school settings (U.S. Department of Education, 2015). Another resource that is available regionally throughout the U.S. are the Pediatric Environmental Health Specialty Units (PEHSU). These units are based in academic-affiliated medical centers and are staffed by healthcare providers with expertise in issues related to pediatric and reproductive environmental health. Their faculty and staff work closely with local, state, and federal health officials, consulting on a variety of environmental issues involving the health of children and their families. PEHSU personnel can advise school district leadership, local school committees, and local boards of health about the properties and potential health effects of chemicals stored and used on school properties, and explain the safety measures that should be considered to address and remediate potentially hazardous situations (PEHSU, 2017).

Despite the various resources available, acute chemical releases continue to occur in school settings. The adverse public health consequences associated with school chemical releases highlight the need for enhanced collaboration among public health and environmental agencies, individual schools, school boards, parent and teacher organizations, and elected officials in ensuring best practices are used. Additionally, there is a need for future tracking of acute chemical releases in school settings and the health outcomes associated with such releases. Tracking chemical releases can help schools allocate limited resources for promoting health in the school environment. 🌱

Disclaimer: The findings and conclusions in this article are those of the authors and do not necessarily represent the views of CDC/ATSDR.

Corresponding Author: Ayana R. Anderson, Agency for Toxic Substances and Disease Registry, 4770 Buford Highway, Atlanta, GA 30341. E-mail: ing9@cdc.gov.

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